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THE COLOUR-SENSE:

Its Origin and Development.

AN ESSAY IN COMPARATIVE PSYCHOLOGY.

BY

GRANT ALLEN, B.A.,

AUTHOR OF "PHYSIOLOGICAL ÆSTHETICS."

LONDON:

TRÜBNER & CO., LUDGATE HILL.

1879.

PREFACE.

THE materials which form the nucleus of the present volume were originally collected as part of the basis for a chapter on "the Genesis of Æsthetics" in my little work on "Physiological Æsthetics," published some two years since. I found, however, when I came to arrange them, that the subject had grown under my hands, and that it would be impossible fully to develop my ideas except in the form of a separate treatise. The omission seemed all the more desirable, because my former work dealt only with Æsthetics as an element of human psychology: while the materials here collected refer rather to the wider science which studies the phenomena of mind throughout the whole animal world. Accordingly, I deferred their publication for the time, only mentioning my original intention in a footnote on p. 156 of "Physiological Æsthetics." But most of the critics who kindly noticed that little work were so unanimous in calling attention to the hints which I had thrown out with reference to the Colour-Sense, and the love for colour which forms such a striking characteristic of mankind, that I determined on following up the subject on a wider basis, and elucidating my view by full inductive generalisations. The present volume is the result.

Meanwhile two works appeared, in Germany and in England, which necessitated considerable divergences from my original plan. The first was Dr. Hugo Magnus's "Geschichtliche Entwickelung des Farbensinnes;" the second Mr. A. R. Wallace's "Tropical Nature." Put shortly, the gist of my theory was this: that the taste for bright colours has been derived by man from his frugivorous ancestors, who acquired it by exercise of their sense of vision upon bright-coloured food-stuffs; that the same taste was shared by all flower-feeding or fruit-eating animals; and that it was manifested in the sexual selection of brilliant mates, as well as in other secondary modes, such as the various human arts. The two volumes mentioned above came like utterly destructive criticisms of any such belief. Dr. Magnus endeavoured to prove that the Colour-Sense of mankind was a late historical acquisition of the race, whose beginnings hardly dated back as far as the Homeric and Vaidik periods. Mr. Wallace controverted, with all his well-known vigour and ingenuity, the theory of sexual selection, first announced by Mr. Darwin, upon which rested almost the whole argument for a love of pure colour among the lower animals. Thus these two books between them cut away the whole ground from under my feet. It became necessary to go back over my materials afresh, and to seek for evidence against both anticipatory assailants. I have tried, therefore, to show, in opposition to Dr. Magnus, that the Colour-Sense of mankind dates back to the earliest appearance of our race upon earth; and, in opposition to Mr Wallace, that a modified form of the sexual selection theory may still survive his powerful attack. I am aware how ill prepared I am to encounter so thorough a biologist as the joint discoverer of Natural Selection on his own ground; but I have humbly offered such arguments as lay in my power, trusting to the generosity of my opponent to forgive any technical errors which may easily creep into a discussion of the sort.

I should like to add that I enter the lists as a comparative psychologist, not as a biological student. I do not pretend to discover facts of botany or zoology at first hand: I accept them as data from the lips of competent specialists. Yet I hope my work may prove valuable in its own peculiar sphere, which ought to be kept distinct from the objective biological sciences whose conclusions form its basis. Our great naturalists supply us with the facts upon which to build our comparative psychology: and I hope there is no presumption in employing them sometimes to test the logical correctness of a few among the naturalists' own conclusions.

One of the main necessities of science at the present day is the existence of that organising class whose want was pointed out by Comte, and has been further noted by Mr. Herbert Spencer. To this class I would aspire, in a humble capacity, to belong. But the organising student cannot also himself be a specialist in all the sciences whose results he endeavours to co-ordinate: and he must, therefore, depend for his data upon the original work of others. If specialists find technical errors in such coordinated results, they should point them out frankly for correction and improvement, but they should not regard them as fit subjects for carping criticism. I shall feel grateful to any biologists who can suggest alterations or modifications in any part of what I cannot but feel a very tentative and rudimentary work. But unless we make a beginning in psychology we shall never reach the end: and I send forth my speculations rather in the hope that they may arouse comment and lead to further researches, than because I consider them in any way final or complete.

With regard to the authorities used or quoted, I have followed the plan of making no references to original works when dealing with the accepted common-places of science; but wherever I have occasion to note a particular fact, of comparatively modern ascertainment or specialist knowledge, I give the authority in a footnote. For the general groundwork of my theory, my acknowledgments are mainly due to the works of Mr. Darwin and Mr. Herbert Spencer, which I seldom quote by name, because they now form part of the established body of scientific doctrine. After these, I owe most to Mr. A. R. Wallace, Mr. Bates, and Mr. Belt. For personal assistance, by letter or otherwise, I must thank Mr. Darwin, who supplied me with corrections on the colours of flowers; Mr. Wallace, who kindly wrote to me with regard to the colours of fruits; Mr. Galton, F.R.S., for an introduction to the library of the Royal Society; Mr. Gladstone, who called my attention to notes in German periodicals; the Rev. A. H. Sayce, for reference to Assyrian and Babylonian works of art; the Rev. T. K. Cheyne, for aid on the question of Hebrew colour-terms; Mr. H. N. Moseley, naturalist to the *Challenger* expedition, for references to papers on the colouration of deep-sea organisms; Sir John Lubbock and Mr. B. T. Lowne, for copies of their original researches on the eyes and optical perceptions of insects; and the Rev. S. J. Whitmee of Samoa, with a large number of other missionaries or civil servants, for information with regard to the Colour-Sense of savages.

In a more strictly personal sense, I owe my acknowledgments to my friends, Mr. F. T. Richards of Trinity College, Oxford, Mr. G. J. Romanes, F.L.S., and Professor G. Croom Robertson, for constant assistance in calling my attention to passages in books or periodicals which bore on the subject under investigation.

Finally, I should mention that, although most of the matter contained in the present volume is entirely new, I have incorporated into Chapters IV. and VI. the substance of two papers on "The Origin of Flowers" and "The Origin of Fruits," which appeared in the "Cornhill Magazine" for May and August 1878. Part of the materials for Chapter X. were also included in a note which I contributed to "Mind" for January of the same year.

G. A.

CONTENTS.

THE COLOUR-SENSE.

CHAPTER I.

INTRODUCTORY.

THERE is no element of our sensuous nature which yields us greater or more varied pleasure than the perception of colour. Whether we look at the larger physical wholes, the azure heaven above us, the purple sea beneath us, and the green meadows by our side;—or at the smaller organic bodies, the brilliant flowers, the crimson foliage of autumn, the gaudily painted butterflies, the beetles clad in burnished gold, the peacock adorned with all the hues of the rainbow, and the humming-birds decked out in ruby, sapphire, and amethyst;—or again at the transient effects of light in the spectrum, the soap-bubble, the iridescent surface of the opal, the tints of eventide mirrored in the glassy lake;—in each and every case we feel a thrill of pure and unselfish enjoyment, which no other mere sensuous stimulation is capable of arousing in our breasts. The pleasure of colour is one which raises itself above the common level of monopolist gratification, and attains to the higher plane of æsthetic delight.

Nor is man the only creature who can appreciate and enjoy the lavish store of beauty which nature pours forth for his pleasure in the fields and the forest. We shall see reason to conclude, from the facts collected in this volume, that many of our dumb relations can fully enter into the love for exquisite colour, at least in its simplest and earliest forms. We shall find good ground for believing that the bird of paradise does not display its gorgeous plumage to the careless eyes of an unobservant mate; that the gaily painted butterfly is not insensible to the lovely tracery upon the wings of its fellow; and even that the tropical lizards or batrachians can duly admire the glistening coats, crimson crests, or golden pouches of their lissome helpmates. We shall further note certain habits which may lead us to suspect that birds and insects are pleasurably affected, not only by the colour of their own kind, but also by the delicate or brilliant tints of the fruits and flowers upon which they feed. In short, our object must be to trace back the pleasure which man experiences from the deft combination of red and green and violet, in painting or in decorative art, to a long line of ante-human ancestry, stretching back indefinitely through geological ages to the first progenitors of vertebrate life.

More than this we must attempt to show. If we would learn fully the whole history of the colour-sense, we must track it backward through the generations of the earlier earth, till we discover what were the circumstances by which it was first produced. We must find out how the various modes of æther-waves, which we now know as colours, came originally to be distinguished from one another by the nascent eyes of half-developed reptiles and insects. We must see by what steps the hues of flowers, and seeds, and fruits, and small animal prey caused the growth of a distinctive colour-perception in the creatures which fed upon them. And we shall probably conclude at the same time that the sense thus developed became in turn a source of new pleasure to its possessors, and a groundwork for more marvellous developments in future. The taste which was formed by the lilies and roses, the golden oranges and purple grapes, ended by producing the metallic lustre of the sunbirds and the daintily shaded ornamentation of the argus-pheasant.

We may hope to show, furthermore, that the existence of bright colouring in the world at large is almost entirely due to the influence of the colour-sense in the animal kingdom. I do not mean, of course, that animals have anything to do with the objective existence of those different æther-waves in the pencil of light which, when decomposed or separated, we perceive as colours; nor do I mean to include in this category the shades of earth, sea, sky, and other great inorganic masses. Obviously the human or animal eye could have no influence upon their origin or colouring. Even the green leaves of the trees and grasses seem quite independent of man or beast. But I still think that a vast mass of the coloured objects with which we are most familiar owe their hues to the perceptions of some insect, bird, or animal. If we look briefly at a few of the best-known cases, the reader will more clearly comprehend the line of argument which this book proposes to itself.

In the drawing-room where we sit, every object has obtained its colour entirely with reference to the likes and fancies of humanity. Not only have the pictures and ornaments been painted so as to please our eyes, but the carpets, the wall-paper, the curtains, the table-covers, the embroidery, the damask on the chairs and sofas, the clothing of the women and children, have all been dyed on purpose to stimulate and gratify the sense of sight. Indeed, there is scarcely an article of human use and manufacture, from the vermilion-stained earthenware of the prehistoric savage and the woad adornment of the Cymric warrior, to the Lambeth and Vallauris pottery, or the cretonnes and crewel-work of modern æsthetic designers, which has not received some special manipulation to add pleasing colour by means of dyes or pigments. The universal effect of the colour-sense on human products is too obvious to need further illustration.

A step lower down, we reach the actual bodies of men and animals themselves. It would seem at first sight as though the colour-sense could have nothing to do with the production of these. Yet the theory of sexual selection, into which we shall enter more fully hereafter, shows us how the long-continued choice of beautiful mates may have had the effect of encouraging the growth of bright-hued individuals, and the obsolescence of their less favoured fellows. I shall try to point out, also, an adjunct to this theory, which seems to have escaped even the keen eyes of Mr. Darwin, Mr. Wallace, and their German allies. I shall endeavour to prove that only those animals display beautiful colours, due to sexual selection, in whom a taste for colour has already been aroused by the influence of flowers, fruits, or brilliant insects, their habitual food. As the liking cannot have grown up without some groundwork of advantage to be gained by it, we might gather, even *a priori*, that such would be the case; and I hope, in the sequel, to adduce a sufficiently large array of positive instances to justify an inductive conclusion to the same effect.

Taking still another step backward, we arrive at the brilliantly coloured fruits and flowers, upon which these tastes were formed. And here we shall have reason to believe that the agency of insects has been most powerful in developing the hues of blossoms; while the fruits, as we shall see, are rather due to the selective action of birds and mammals. Between them almost all the colours of vegetal life, except the uniform green of the foliage, are probably produced, being due to the colour-sense of one or other of the great seeing classes, the vertebrate and the articulate.

Many lesser cases may be alleged, where colours have been acquired for purposes of protection or deception, and of such an abundance will be forthcoming in their proper place. But enough has doubtless been said to show the immense importance of the colour-sense in man or animals, and the conspicuous part which (as I believe) it has played in the moulding of organic forms. If I put in two antithetical paragraphs the various great classes of coloured objects which we do or do not owe to its operation, the reader will be able to see at a glance just how much influence I claim for it.

We do not owe to the colour-sense the existence in nature of the rainbow, the sunset, or the other effects of iridescent light; the blue sky, the green or purple sea, the red rocks, or the other great inanimate masses; the foliage of trees and shrubs, the hues of autumn, and the tints of precious stones or minerals generally.

But we *do* owe to the colour-sense the beautiful flowers of the meadow and the garden,—roses, lilies, carnations, lilacs, laburnums, violets, primroses, cowslips, and daisies; the exquisite pink of the apple, the peach, the mango, and the cherry, with all the diverse artistic wealth of oranges, strawberries, plums, melons, brambleberries, and pomegranates; the yellow, blue, and melting green of tropical butterflies; the magnificent plumage of the toucan, the macaw, the cardinal-bird, the lory, and the honeysucker; the red breast of our homely robin; the silver or ruddy fur of the ermine, the wolverine, the fox, the squirrel, and the chinchilla; the rosy cheeks and pink lips of English maidens; the whole catalogue of dyes, paints, and pigments; and, last of all, the colours of art in every age and nation, from the red cloth of the South Seas, the lively frescoes of the Egyptian, and the subdued tones of Hellenic painters, to the stained windows of Poitiers and the Madonna of the Sistine Chapel.

The origin and rise of this powerful sense, and the means by which it has effected all these marvellous reactions on the external world, form the text upon which we must string our discourse in the present volume. We shall begin with the nature of colour, viewed as an external and objective fact; we shall next look at the steps by which the various eyes of insects and animals became sensible to its diverse stimulations; we shall then proceed to ask what secondary effects the newly acquired sense produced upon the surrounding existences; and we shall finally examine its remote æsthetic results in the sphere of human activity. We shall thus have traced the perception of colour from its first faint beginnings in palæozoic seas or carboniferous forests down to its latest developments in the palaces or galleries of civilised man.

CHAPTER II.

ÆTHER-WAVES AND THEIR VARIETIES.[1]

BEFORE we can investigate any sensation in men or animals, we must find out what is the external agency to which it corresponds. Every feeling answers to some outer fact, and in the development of life the fact must necessarily have preceded the feeling. Unless there had been matter there could never have been mind. Without resistance we could not experience touch; without air we could not possess hearing; without æther we could not have developed the wonderful faculty of sight. Organic substances, acted upon by peculiar agencies in the inorganic world, give rise to the phenomena of sensation; but we cannot understand the existence of sensation unless we previously grant the existence of an influence capable of developing it. Idealism, which looks fallaciously plausible when applied to the fully evolved intelligence, becomes meaningless and self-contradictory when applied to the problem of its evolution.

[1] In the short sketch of Physical Optics which follows, I have endeavoured, not to give a *résumé* of all that is known upon so wide a subject, but merely to say as much as was absolutely necessary for the proper comprehension of the sequel. Hence I have intentionally omitted whatever might prove a stumbling-block to the general reader, such as the difference between absorption colours and interference colours, or that between mixture of lights and mixture of pigments. Such questions are wholly foreign to our present subject, and I merely note the omission to guard against possible criticism. The reader who would go further into this department of the subject will find full details in Helmholtz's "Handbuch der Physiologischen Optik," and a very readable abstract in Von Bezold's "Theory of Colour," translated by S. R. Koehler (Boston, U.S.A., L. Prang & Co., 1876).

We must begin, then, by allowing that, previous to all perception of colour by men or animals, colour itself existed as an agency in the external universe. The development of the colour-sense is equivalent to the growth of a mechanism by which this agency became capable of affecting organic matter. In the present chapter we will consider the nature of the objective agency, while in the next we shall have to look at the first and rudest form of the percipient mechanism.

Throughout the whole vast ocean of space in which suns, stars, and planets float like inconspicuous islets of light, modern science has taught us that an all-pervading element, known as æther, fills every available interstice. From constellation to constellation of sidereal bodies the æther spreads in wide expanses, which stretch uninterrupted over countless millions of miles. Between atom and atom of terrestrial substances the æther penetrates into tiny intervals whose minuteness the boldest mathematicians have only lately ventured to measure. Whereever matter is not, æther is. Every sun and every molecule floats in a circumambient matrix of this unknown agent. If we could view the most solid body with a microscopic eye, magnifying some thousands of millions of diameters, we should see that it was composed of innumerable little masses, none of them in actual contact with its neighbours, but all bound to one another, as the earth is to the sun, by their mutual attractions extending over an intervening space. This space would be filled, in the one case as in the other, by the ubiquitous æther. And though we can never succeed in knowing its existence directly, yet we are every moment experiencing its effects in the most obvious and unmistakable manner. Just as we believe in air, which we never see, because we can feel it, so we believe in æther, which we can never handle, because we perpetually see by it and through it.

Æther, though infinitely light and elastic, is naturally a solid, or something very like one. But it shares the common property of other solids in its ability to transmit undulations from a centre of disturbance. We all know that if we set any body in motion, it imparts a portion of its motion to all other bodies with which it comes in contact. So, too, if we set up vibratory movements in a bell, we know that its particles knock up against the air-particles in their neighbourhood, and thereby send off into surrounding space a series of concentric air-waves, which, when they strike the appropriate human organ, are known to us in consciousness as sounds or tones. And in exactly the same way, when disturbances of a peculiar kind affect material particles of any sort, they set up a like series of concentric waves in the circumambient æther, which, falling in turn on *their* appropriate organs, are recognised in consciousness as heat, light, or colour. What is the exact nature of these waves and their differences we have next to inquire.

Apparently every movement of a material body or particle sets up more or less motion in the surrounding æther. We know now that every sound, every moving energy, every activity of any sort, as it dies away, is transferred by minute friction to the ætherial medium which bathes us on every side. But the stronger class of æther-waves, with which we have now to deal, is originated only in a single way. They all arise from the vibrations of a material body in that state of rapid molecular or atomic motion which we commonly know as red or white heat. The waves thus set up may be reflected, refracted, twisted about, and returned in varying proportions by other surrounding objects, but they all owe their original existence to a heated material mass, whether that mass be the sun, the dog-star, the drawing-room fire, or the flame of a candle. So we must look for a moment at the source of such æther-waves before we can comprehend the nature of the waves themselves.

Directly or indirectly, in every case, the vibration of the original heated body is due to the rushing together of masses, molecules, or atoms which were previously in a state of separation. In the heavenly bodies, the sun and the fixed stars, the attraction of gravitation (which affects masses) is drawing together their skirts; and under its influence the outlying matter of their systems is clashing with the central sphere and producing a terrific degree of heat; just as the continued clashing of hammers on an anvil will heat a piece of iron red-hot here on our little earth. In the grate and the candle, again, the attraction of chemical affinity (which affects atoms) is drawing together tiny particles of carbon and oxygen; and as the atoms clash against one another in the embers or the flame, they are put into a similar state of rapid vibration or heat. In physical language, the potential energy of their previous separation has become kinetic in the act of union, and is now being radiated off to surrounding objects. As the quickly vibrating little bodies, either in the sun or the flame, fly from side to side, they impart each second a portion of their moving energy to the æther about them; and each ætherial molecule continues to impart the communicated impulse to adjacent molecules, so that a series of spherical waves is set up in every direction from the central disturbance. If nothing intervenes to prevent them, these waves go on widening and weakening through all space *ad infinitum*, at least as far as human science or conjecture can follow them.

But all the æther-waves are not of exactly the same size, nor do they follow one another with exactly the same rapidity. When a material body vibrates with a comparatively slight motion (or, as we say in other words, is only slightly heated), the waves to which it gives rise are comparatively slow and voluminous: as the rate of vibration increases, more rapid waves succeed in the surrounding æther; and when the rapidity of vibration becomes very great, the resulting waves follow one another with an almost incredible speed. Three principal varieties of slower or quicker æther-waves are commonly distinguished, according to the effects which they produce upon the human organs.

The slowest undulations are known as heat-waves; those of intermediate rapidity as light-waves; and the quickest of all as chemical waves.

All three classes of waves are produced together by a body in a state of high molecular energy, such as the sun. Fortunately, we are able to separate the various kinds from one another, and to demonstrate their several properties, by means of a simple piece of triangular glass, known as a prism.

If we make a small slit in the shutter of a darkened room, and allow a few of the æther-waves, generated by the sun, to enter through this aperture, we can interpose the prism across their path, and project them sideways on to a screen. When we do so we find that the various waves are all bent upward, but not all equally. They occupy a broad space on the screen, the slowest waves striking the lowest portion, and the quickest falling at the top, while those of intermediate speed hit the middle space.[1] If we put a thermometer of very delicate construction (known as a thermopile) at the lowest point where the waves surge against the screen, we shall find that, in this portion of the wave-bundle, the undulations possess great heating power. If we put a piece of specially prepared paper at the highest point where the waves alight, we shall similarly find that the undulations of that region possess high chemical power. And if we look at the intermediate space, we shall see for ourselves that the waves of that part produce the greatest amount of light and colour. So here we learn that in every bundle of solar æther-waves these three classes of undulations are closely combined; but by the interposition of a proper medium they can be sifted and separated each into a place of its own.

[1] As my purpose is here to explain the *objective* nature of colour, I am careful to avoid any allusion to the *subjective* differences of perception.

Fundamentally, then, light and radiant heat are identical. And not only so, but a third order of rays—the chemical—is always bound up with them in the waves which come to us from the sun. Yet though in their objective nature these various agencies are so similar—differing not at all in kind, but only in degree—there is a very strange diversity in our subjective perception of their effects. The slowest æther-waves we perceive with every portion of our bodies, and know as heat; the intermediate æther-waves we perceive through a pair of small and special organs—the eyes—and know as light; while the fastest æther-waves we do not perceive at all, except by very roundabout and indirect means.

The reasons for this difference must surely be very striking ones. It seems curious that such similar agencies should be so diversely cognised, or should escape our cognisance altogether. And it is for the purpose of bringing into clear relief so strange a fact that I have chosen what doubtless seemed at first sight an awkward and unfamiliar mode of envisaging a well-known subject. The question why we have two distinct methods for perceiving two closely allied forms of æther-waves, and no method at all for perceiving the third, is a question which evolutionism is bound to answer before it proceeds to the minor discrimination of those lesser differences known as colours.

For when we look at the matter objectively, we see at once that each colour differs from its neighbour in just the same manner as heat differs from light, though only to a less degree. Accordingly, we must ask first, Why are the senses of animals so differently affected by the extremes and the mean of the solar undulations? And when we have answered that question we may go on to the next, How did the various minor undulations of mean rapidity come to have differential sensations attached to them in consciousness?

Fortunately, the answer is not a very difficult one. The slower and more massive undulations, which we know as heat-waves, produce very marked results even upon inorganic bodies, while their effects upon organic matter are obvious and enormously important. To the animal, cold is death and warmth is life. Hence it is not astonishing that animals should very early have developed a sense which informed them of the changes of temperature taking place in their vicinity; and that this sense should have been equally diffused over the whole organism. Æther-waves of slow vibration are capable of setting up motion in the molecules of all bodies upon which they impinge, as we know familiarly when we touch a stone on the summer beach, or grasp a poker which has lain long in front of the fire; and the motion so absorbed we call warmth: while, on the other hand, molecules in rapid motion give up their energy to the surrounding æther, as we also know when a red-hot poker cools, or when we expose our faces to the chilly wind of winter; and the loss of motion so induced we call cold. In either case, the immediate effects are so highly important to animal life, that we may well imagine the accompanying sensations to be amongst the earliest which evolution could have produced. As soon as moving creatures began to feel at all, they probably began to feel heat and cold.

The æther-waves of middle frequency, however, do not produce such plain and universal results. If we interpose a slab of rock-salt in the course of a solar beam, we can sift out of it all the slower undulations (or heat-waves), which are selected and absorbed by the salt itself. On placing our hands in the path of the remaining wavelets, we do not experience any feeling of heat whatsoever. And if we put a piece of inorganic matter—say a pebble —in the course of the sifted ray, we shall find that it is similarly unaffected in temperature or structure. The thermopile conclusively shows us that little or no immediate mechanical power is left in the wavelets which pass through the rock-salt. If we examine the results which these middle undulations produce upon the world at large, we shall arrive at similar conclusions. While to the heat-waves are due the conspicuous differences of summer and winter, ice, snow, and rain, the poles and the tropics, besides the great phenomena of ocean-currents, winds, evaporation, clouds, rainfall, and atmospheric disturbances generally; their companions, the light-waves, scarcely produce any noticeable effects at all. Falling upon the mass of the earth's surface, they are not, like the slower undulations, absorbed and communicated through the substance on which they impinge, but are reflected and twisted back upon space in every possible direction. Even if they are partially taken in by the matter on which they fall, yet the greater portion of them are returned without effecting any change in its arrangement; and if, as in the case of what we call a black surface, a large number or the whole of them are absorbed and retained, they are yet degraded by the process into the form of heat-waves, from which they cannot be consciously discriminated except by indirect means. These middle waves could not, therefore, prove of any great importance to animal life in its earliest days; and we need not wonder that no sense for their perception was at first developed.

There is one conspicuous exception, however, to this comparative inertness of the light-waves—I mean the case of plants. In their leaves, the middle and quickest ætherial undulations become the agents for effecting great chemical and physical changes, upon which the whole course of mundane life entirely depends. But these facts, all-important in themselves, do not directly affect our present question. Light is essential to animal life, because it is essential to the plants upon which, mediately or immediately, animal life subsists. But a perception or discrimination of light is not at all necessary, except in a very roundabout and derivative way. Why it has arisen at all we may next briefly inquire.

The light-waves falling upon a body do not largely affect it, as a rule, in any way. They may occasionally be employed in bringing about slight changes of its superficial molecules, but they do not penetrate deeply or work conspicuous rearrangements of its whole substance. Nevertheless, the power of discriminating them may indirectly benefit an animal organism. If a jellyfish, swimming at the water's top, has eyelets upon which the incident light-waves produce distinct effects, it may be warned of the approaching enemy, or informed of passing prey, by having the path of the æther-waves cut off from above. Still more valuable will the nascent sense become, if, instead of being restricted to the full force of directly incident undulations, it is capable of being impressed by reflected waves. In this case, not only will the creature be conscious of objects passing between it and the source of light, but it will be able to receive varying stimulations from all surrounding objects upon which the light falls. The more highly developed its sight becomes (for we may now use the language of ordinary life without fear of ambiguity), the more clearly will it be affected by the beams which are twisted about and returned upon space from every neighbouring body. Until at last that very fact in the light-waves which made them originally so unimportant—the fact that they glance off every object they hit like a ball rebounding from a wall—gives them, in our eyes, the greatest value, by enabling us to discriminate from a distance the shape and texture of all we see, without the trouble of actual examination by the hands and fingers.

But this specialised sense is hardly likely to spread itself over the whole body, like the sense of heat and cold. Not only should we derive no advantage from being all eye, but we should be positively incommoded rather than benefited by such an arrangement. It will only be in certain special spots or *ocelli* that the perception of light will probably begin; and as the sense strengthens, we shall find these spots becoming fewer and fewer, until in the approximately perfect organisms they are reduced to the two conspicuous orbs which we commonly call eyes. All such questions, however, must be left over for a while, until we come to examine the development of the rudimentary vision. At present we must hurry on to reach our proper subject—the objective nature of colour.

As for the third class of ætherial undulations, the quickest or chemical waves, their effects are so slight and inconspicuous that we have never had occasion to develop any sense whatsoever for their perception. It is only quite recently, and by quite indirect methods (chiefly through the investigations of the earliest photographers), that we have come to recognise their existence at all. Neither upon inorganic substances nor upon animal bodies do they produce any striking result; so that we need not wonder at our inability to perceive them, either with our whole organism or with any specialised organ. Whatever has no influence upon our welfare as a species can never have any effect upon the modification of our senses.

We can dimly understand, then, why these three kinds of æther-waves, differing from one another only in their relative size and frequency, should be commonly thought of as such utterly unlike agencies. The slowest waves affect all material substances alike, and are consequently cognised by our whole bodies as heat. The middle waves are cast off in varying proportions by almost every substance upon which they fall, but possess little power of modifying their arrangement, and are consequently cognised by a very special organ—the eye; while the quickest waves are almost inert, so far as our present purpose is concerned, and are consequently not cognised by us at all, except mediately and intellectually.

And now that we have seen the objective nature of light in general, let us ask what is the objective nature of colours in particular.

As I said above, each colour bears objectively the same relation to light as light itself, heat, and chemical rays bear to the whole set of ætherial undulations.

If, once more, we have recourse to the prism and the darkened room, we can throw a bundle of æther-waves as before upon a white screen. Neglecting now the two extremes, the heat-rays and the chemical rays, which are of course invisible, we need only concern ourselves with the middle or light-rays, which form a bright band of colours, ranging from red to violet. The lowest part of this band or spectrum, next to the place where the thermopile showed us the existence of the heat-rays, is occupied by red. After it, in ascending order, come orange, yellow, green, and blue; while the highest place, next to the point where the sensitised paper showed us the existence of the chemical rays, is filled by a belt of violet. Each of these colours answers to a set of æther-waves, whose frequency is intermediate between that of heat-rays and chemical rays in the order just given. Slowest of all visible rays are the red, next come the green and blue, while the violet are the quickest waves capable of producing any direct effect upon the eye.

In the case of such a solar spectrum, we have sifted out the various orders of æther-waves by means of their varying *refrangibility*, that is to say, the extent to which each is capable of being bent aside from its direct course by means of the prism. But there are other ways in which the same effect may be produced. For example, we may intercept the whole bundle of compound undulations with a piece of specially prepared glass, (red glass, as we call it), which sifts out all the quicker waves, leaving only the red, just as the rock-salt sifted out all the heat-waves. Similarly, we may take a piece of green, blue, or violet glass, which will cut off all but the proper kind of waves which it is intended to let through. Neither of these ways, however, is a common one in external nature. The rainbow shows us the solar spectrum, and the green light which has passed through a stratum of water gives us an instance of selective absorption; but the way in which ordinary colour is produced is a slightly different one.

We saw above that every æther-wave has its origin in an incandescent body, celestial or mundane. But most of the objects which we see every day are not themselves incandescent; the light by which we perceive them is reflected from the sun. Now when the light-waves from the sun strike upon any terrestrial object, they may be reflected in a great many different manners. If the surface upon which they fall is perfectly smooth and quite opaque (or incapable of transmitting the undulations through its substance), the waves will be returned in their entirety,[1] as when we see an image of the sun in a mirror. Here the waves are sent back as they came, exactly in the same way as when a ball rebounds from the wall. If, however, the surface is not quite smooth, but yet has no special selective power for any one set of waves rather than another, the light is then returned, not directly as it came, but dispersedly in every direction. Such an object is said to be white, and its mode of treating the light may be compared to the case of a stone thrown against a wall, and shivered in every direction into a thousand pieces. Again, if the surface has such a molecular disposition that it absorbs or neutralises one or more sets of waves, and only returns one or more other sets, then it is said to be coloured. If it absorbs all the green, blue, and violet rays, returning only the red, then it is said to be a red object, because the red rays alone strike our eyes when we look at it. Similarly, if it absorbs all the red, orange, and violet rays, returning only the green, it is said to be a green object. And so on throughout. Lastly, if it absorbs all the æther-waves, degrading their light into the form of heat, and returning none, it is said to be black.[2]

[1] I am speaking broadly, and purposely neglect minute and tedious details.

[2] I trust the critical scientific reader will forgive me for simplifying the question by omitting all reference to inner reflexion and other minor points.

Almost every object upon which the sunlight falls possesses a power of selecting and returning various æther-waves in varying proportions. Were it not so, the sense of sight could never have been developed. If all objects alike absorbed all the rays which fell upon them, then the whole earth would be one unbroken sheet of black, and the only visible things would be the sun and the fixed stars. If all objects alike reflected all the rays which fell upon them, then the whole earth would be one mass of dazzling white, without distinction of shape or colour. But as each object reflects and disperses the light in different ways from every point of its surface, the discrimination of form, of light and shade, and of colour becomes possible. The existence of the two first-named faculties we must take for granted in this work, though we shall have somewhat further to say about them in the succeeding chapter. But the discrimination of colour, the proper subject of our treatise, demands a little more detailed treatment even at this preliminary stage.

By colour-perception, then, we shall understand in the present work *the power of discriminating between light-waves having different rates of frequency.* If any creature shows by its actions that it is endowed with such a power, we shall say that it possesses a colour-sense. Anything more than this it is impossible to prove. Whether the sensation or mental idea *blue,* as perceived or thought by a butterfly or a humming-bird, is the same in consciousness with the sensation or mental idea *blue* as perceived or thought by you and me, we can never know. For, observe, we can never even know, gifted with language as you and I are, whether my perception of blue is the same as yours; far less then can we know this same thing in the case of animals whose minds are so widely diverse as man's and the butterfly's, and between whom intercommunication is impossible. But we *can* know by means of language that certain objective differences which differentially affect me also differentially affect you. And so too we *can* know, by the testimony of voluntary or automatic action, that these same objective differences which differentially affect us two, in like manner differentially affect birds, fishes, and insects. Such a power of being differentially affected in the particular case of medium æther-waves having quicker or slower rates of recurrence, we call the colour-sense.

Moreover, just as, in spite of this logical and metaphysical difficulty, no two human beings ever seriously and really doubted the practical and essential identity of their respective sensations, so too in the case before us, I think we shall find such a general agreement in the likes and dislikes of taste, smell, sound, and colour, running through two large groups of animals, whose general habits of life coincide in the main, that we shall not hesitate practically to assert the correspondence of *our* idea of colour with that of beasts, birds, fishes, and insects. That we can *prove* this correspondence no one could for a moment maintain; but that we should *believe* it without strict proof, is not, it seems to me, a very dangerous precedent. Rather should we hesitate to introduce into our conception of the uniform order of nature any supposed difference in kind without full and weighty reason.

A few words more, before we close this unavoidably tedious preliminary statement, as to the nature of the colours objectively existent in nature. As a rule, the bundles of æther-waves which fall upon terrestrial objects are not directly reflected (in other words, the world is not made up of innumerable mirrors); nor are they dispersed in their integrity (in other words, the world is not a sheet of snowy white); nor are they all wholly absorbed (in other words, the world is not a pall of sombre black). A few objects have such surfaces as to reflect totally, like looking-glasses, mercury, or calm water; a few others have such a molecular constitution as to disperse the total beam, like snow-white paper and bleached linen; a few more have such a different molecular arrangement as to absorb entirely, like soot, lampblack, and broadcloth. But most bodies have their molecules so set as to absorb certain amounts or orders of æther-waves and to return certain other amounts or orders. It is these last of which we generally speak as coloured objects.

Practically speaking, black, white, and grey only differ in the *amount* of waves which they reflect and absorb, not in their *kinds*. A black object absorbs nearly all; a white object disperses nearly all; a grey object absorbs some and disperses some, but in nearly equal proportions of the various kinds. These varieties, then, yield us no sensations of colour proper, but rather of light and shade.

But many objects—the vast majority of objects, in fact—do not reflect the various constituents of the total wave-bundle in their entirety or in equal proportions. They have such a molecular constitution that they select from the waves which fall upon them certain special waves, whose frequency is the same as their own natural rate of oscillation, or else a multiple of the same. All others they reject and reflect back upon the æther without. It is these reflected waves which fall upon our eyes and yield us the sensation of colour.

Very few natural objects, again, outside the organic class, yield us pure colours. Most of them are of dull mixed hues, like the various earths, sands, rocks, and clays. A very small and highly prized class of inorganic bodies do, indeed, reflect light of a single sort only, as in the ruby, the topaz, the amethyst, and other precious stones. But, as a rule, inorganic bodies, as found in nature, are dull browns, dingy greys, or muddy whites. When we turn to the organic world, however, we find pure colours—that is to say, æther-waves of single or slightly compounded orders—very prevalent. In the green leaves of trees, the brilliant tints of flowers, the lovely hues of fruits, the wings of butterflies, the feathers of birds, we find colour constantly appearing in very pure forms. We shall see reason in the sequel to conclude that these pure waves, rather than the mixed and confused systems of inorganic nature, have given rise to the perception of colour in animal organisms.

And now let me briefly sum up the points which I have been endeavouring to italicise in this preamble. Colour, objectively viewed, is nothing more or less than the different rate of oscillation in different æther-waves. The colour-sense, subjectively viewed, is an exaggerated difference of perception attached to the effects of these external agencies, which really differ so very little between themselves. And the problem of its origin is this—How did these slight differences in the frequencies of æther-waves reflected from various organic or inorganic bodies come to have such disproportionately diverse sensations attached to them in consciousness? In other words, when red light differs from blue light only in degree, why does red differ from blue, as we know them, in kind?

The questions thus proposed our future chapters must endeavour to answer.

CHAPTER III.

THE ORGAN OF VISION.

THE perception of light is not equally valuable to all classes of animals. It seems to be specially connected with the power of locomotion. Sessile or sedentary animals, as a rule, do not possess any form of visual organ; while very free and active animals, even of lower organisation, have well-marked eyes. The Echinodermata, for example, are far more highly evolved creatures than the Medusæ, but their habits are comparatively sluggish, while the Medusæ lead a wandering, predatory life; and we find that the former class are apparently quite eyeless, while the latter have distinct *ocelli*, which in some cases reach a considerable complexity of structure.

Still more clearly is this connection made evident by the metamorphoses of many creatures which pass from a free to a fixed state. The young barnacles and *balani* are active, locomotive animals, furnished with eyes, antennæ, and limbs; but after a period of activity, they finally fix themselves upon some solid object, and undergo a loss of all their higher sense-organs. Similar changes take place among the parasitic Entomostraca, the Tubicolar Annelids, and many Mollusca. These must be regarded as cases of degradation or retrogressive development.

Conversely, the Medusæ are shown, by their peculiar mode of development, to be the descendants of hydraform polypes. During their sessile stage, when they exactly resemble the true Hydroida, they are as destitute of eyes as the other members of that order. But when they acquire their tentacles and assume the free mode of life, the *ocelli* are produced together with the other mature organs. This must be regarded as a case of progressive development.

If we examine the various classes of animals in order, the same general connection between free locomotion and vision will be forced upon us once more. Passing over the Protozoa, which of course are too humble in structure to exhibit any such complex nervous organs as eyes, and beginning with the Radiata, we see that the only class in that division which possesses high powers of locomotion is the Discophora, or jellyfish, and this is also the only class provided with visual organs. Among the Nematophora or Echinodermata, which are all very sedentary animals, eyes are doubtfully present. The lower vermiform Articulata are mostly entozoic, and these of course are quite blind; but the few species which swim freely in water by means of cilia have eyes with distinct lenses. The free leeches have a ring of eyes around the sucking disc. The highest of these vermiform creatures—the Nereidæ, Peripatidæ, and Polyophthalmidæ—are all very locomotive, and all have very highly developed organs of vision. So likewise have the active little Rotifera. The Arthropoda, or true articulates, yield like results. Thus, among the Crustacea, the Cirrhopoda in their fixed state and the parasitic Entomostraca are sightless; but all the higher free crustaceans are provided with eyes, which in the active crab and lobster orders attain a high degree of perfection. The flying insects show us eyes of great complexity, inferior only to the same organs in vertebrates, if even to those. Yet while most of the Hymenoptera (including the wasps and bees) have very acute vision, it is noteworthy that the ants, which have practically lost their wings, are almost, and in some species quite, blind. It is also a remarkable fact that the male and female ants which are winged possess three *ocelli*, wanting in the wingless neuters. Among the Mollusca, in like manner, the lower molluscoid animals, most of which are fixed, have no organs of vision whatsoever; the bivalve mollusks, leading very sedentary lives, are provided only with doubtful *ocelli;* the relatively active univalves have true eyes, but of low organisation; while the free-swimming Cephalopods (cuttlefish and their allies) have eyes as highly developed as those of many fishes. Lastly, the vertebrates, the most active division of any, show us the highest visual organs of all.

We shall have reason similarly to conclude hereafter that the colour-sense, the most advanced mode of vision, is specially strong amongst the flying insects, the fishes (marine analogues of flying creatures), the birds, and the very active forestine mammals. Its high development in these classes is shown as well by the part they have borne in the evolution of fruits, flowers, and coloured organisms, as by their own brilliant hues, the probable result of sexual selection.

Such a general connection between locomotion and vision is exactly what we should have expected from the nature of the case. A sessile animal, lying in wait for its food, can derive little or no benefit from the possession of visual organs. Even if it could see the approaching prey or the nearing enemy, the knowledge of their vicinity would be useless without the power of locomotion, whereby it might seize the one or avoid the other. Accordingly, most sessile animals are provided with very different organs for the prehension of food, and very different means for withdrawal from threatening danger. Some of them possess long floating arms or tentacles, spread out in every direction to catch the passing prey, which they cannot possibly secure unless it actually come within reach of their grasp. These for the most part withdraw themselves from attack into a solid tube, as in the case of the Sertularidæ, the Tubicolar Annelids, the *Balani,* and the Bryozoa; or else curl themselves up into a contracted mass, as in the Hydra, Sea-anemones, Crinoidea, and Rotifera. Others, again, like the bivalve Mollusca, are enclosed for protection in stout shells, and obtain their food by the creation of currents in the surrounding water. A second group, that of the Entozoa, live in the interior of larger animals, often shut off from the access of light, and bathed by the nutritive fluid of their hosts. These, also, apparently find the possession of eyes no benefit to them. Accordingly, animals originally leading a life of either sort here described—sessile or parasitic—seldom or never acquire the power of vision; while animals originally possessing that power, which afterwards adopt either of these modes of life, usually or invariably lose their eyes, and become degraded in many other ways, in accordance with the Law of Parsimony, whereby all unnecessary organs become gradually obsolescent.

On the other hand, any animal which has acquired freedom of motion will naturally derive great advantage from any premonition of food or enemies in his neighbourhood. Such indications will enable him to rush upon the former or to dart away from the latter. There are various modes by which information of the sort may be given, as by those material particles which arouse the sense of smell, or those undulations of the atmospheric or aqueous medium which awaken the sense of hearing; but the waves of æther described in the last chapter form by far the most certain premonition of all approaching or neighbouring objects, and their reactions finally result in the sense of sight. Of course such a sense cannot arise amongst animals which live perpetually in the dark, like the cestoid and nematoid worms, the lob-worm, and the common earth-worm, all of whose freer relatives are provided with more or less perfect eyes; and even those animals which originally possessed visual organs lose them partially or entirely under like circumstances, as we see in the Bopyridæ, Acarina, and many other parasites, the blind moles, and the well-known sightless fish and reptiles of the Kentucky and Carinthian caverns. Similarly, most very deep-sea organisms are blind, though some remarkable exceptions occur. But amongst all the higher free locomotive and open-air or shoal-water animals we find some form of mechanism for the perception of light-waves, developed in rough proportion to the perfection of the motor system.

There is good reason to believe that such a mechanism has been independently evolved, time after time, by several distinct leading orders in all the great classes of animals. The eye of the bee, of the cuttlefish, and of the eagle, have each apparently been separately developed from unlike remote sightless ancestors. Accordingly, the diversity of structure among these organs is so great, that it would obviously be impossible to give even a brief account of their leading morphological peculiarities in a single introductory chapter. It must suffice here to trace out a few of the main steps in the evolution of such organs, from the strictly psychological point of view.

Simple undifferentiated animal tissue, such as we see in the Rhizopoda, is probably more or less affected by incident æther-waves, like many other organic and inorganic substances. But in order to produce even the most vague and indeterminate sensation of light—or rather, sensation having light for its exciting cause, since the sensation itself (if any) is probably quite indefinite in quality —certain portions of the external coat must apparently be specialised by the collection of a relatively large amount of matter unusually sensitive to light, and directly connected with some simple or complex nervous centre. Such spots are always marked by the presence of pigmentary substances, which seem to play an important part in the function of sight. The simplest form in which they occur is that of the *ocelli* among naked-eyed Medusæ.[1] These consist of small masses of pigment cells, surrounding a minute silicious crystal; and they are

[1] Certain more rudimentary *ocelli* may perhaps be found amongst the Mollusca and elsewhere, but as these are apparently degraded forms of higher organs, they may be left out of consideration here.

usually placed on the under edge of the umbrella-like disc. It may almost be doubted whether we can fairly attach the idea of sensation in any form to these very simple animals; but at any rate, we now know with certainty that the *ocelli* are organs acted upon by light, and responsive to its stimulation. Mr. G. J. Romanes, however, the latest investigator of the subject, believes that the eyes of Medusæ are the simplest possible, because the interval between the stimulus and the response is so relatively great that, were it any greater, the animal could hardly derive any advantage from the organs.

In such very rudimentary eyes, the only perception (or affection) possible is that of light or its negation, the latter being probably the most important. We may perhaps dimly figure to ourselves its nature by shutting our eyes and then passing one hand between them and the light. Some such vague consciousness (if any) of a change in the environment, is doubtless the utmost conjectural limit of discophorous vision.

The first step in progressive development from this earliest form of visual organ would consist in a simple increase in the power of distinguishing light from darkness. This step appears to be the principal one taken by the ordinary univalve Mollusca (Gasteropoda), whose eyes probably only inform them of such wide distinctions.

But an eye, to be of any special use, must also give more definite and particular information with regard to surrounding objects, and this information can best be communicated by some mechanism for the perception of form. A single percipient organ, every part of which is simultaneously and equally affected, cannot afford indications of such a sort. In order to obtain definite information as to the shape and disposition of neighbouring bodies, we must have a number of separate sensitive elements, each directed towards a point in the environing space, and subtending a greater or less angle. Every one of these elements must be provided with a nerve-fibre of its own, and connected with some percipient centre. The minuteness of discrimination must depend upon the number of such sensitive elements and the angles which they respectively subtend.

To trace out in detail the gradual steps by which such structures were evolved would be both tedious and difficult, though certain materials exist for the purpose in the simple and compound eyes of insects and their larvæ, and in the eyes of some lower vertebrates. But it will suffice for our present object to describe, in rough generalisations, the means adopted for the purpose in the most perfect eyes, such as those of bees or of mammals. Here a large number of separate nerve-terminals are arranged in a more or less semicircular form, with single or numerous lenses, which cast the æther-waves upon their percipient surfaces. Each such terminal answers to a separate point in the visual field, and the mechanism of the lens is so arranged that æther-waves from that point alone fall directly on its focal surface. Thus every point in the visual field is represented to the mind by an excitation of the corresponding terminal; and the number and position of the terminals affected gives the animal a clue to the shape and place of the object. The interpretation of these visual symbols into tactual and muscular terms becomes apparently automatic or instinctive in many cases.

In the human eye, which may be taken as a fair specimen of that found among mammals generally, the main portions of the mechanism may be thus briefly summarised. The external or optical-instrument portion consists of a viscid lens, whose shape and focus may be altered by muscular contraction, so as to converge at will æther-waves from different sources at varying distances upon a given point behind it. The internal or nervous and percipient portion consists of the retina, essentially a network of nerve-terminals, belonging to two different orders, known as rods and cones. The excitation, in varying degrees, of these terminals, gives rise to the perception of the visual field. When no part is excited, we get the blank form of visual consciousness known as darkness. When the whole is feebly excited, as through the eyelids, we get a faint general consciousness of light. When the whole is excited in the normal manner, the eyes being open and turned toward an illuminated field, we get a consciousness of mingled light and shade, yielding us indications of form. Those parts of the visual field which reflect large quantities of æther-waves yield us the sensation of relative light; those parts which reflect small quantities yield us the sensation of relative shade.

Were an eye so constituted to possess no further powers, the whole visual field would appear to it monochromatic, or rather strictly achromatic, and all objects would look as we see them in a stereoscopic picture. But the human eye is also capable of distinguishing the *quality* of light as well as its *intensity.* Not only can we discriminate between black, white, and grey, between much and little illumination, but we can also discriminate between red, blue, yellow, and green, between æther-waves of greater or less frequency. This last mode of perception—the colour-sense—is the only one with which we are concerned in the present volume; and we shall therefore leave aside all other questions of visual development as foreign to our purpose. Moreover, as our point of view is psychological rather than physiological or anatomical, we shall regard the problem of its origin solely from the mental side, without inquiring into the nature of the mechanism employed or the functions of its various parts.

Any other method of inquiry would at present be premature. Even in the human eye, where the existence of a colour-sense is certain, we know little or nothing about the mode of its production. There are good reasons, it is true, for suspecting that colour-perception is the special function of the cones, while the discrimination of light and shade is set down to the rods; both because we find colour-perception most pronounced in those parts of the retina where the cones are most thickly massed, near the central point, and less active in those parts where they are relatively few, near the periphery;[1] and because the cones are wholly wanting in the eyes of nocturnal animals, which only require to distinguish between light and shade. But the physiology of the cones is much disputed, and the accepted theories can only be regarded as provisional. Moreover, in insects, where the colour-sense is most certain after the human species, we have not even a conjectural hypothesis of the mode in which it acts.

It may, however, be worth while, before we pass on to our proper subject—the origin and development of the colour-sense,—briefly to state the current theory as to the mechanism for the perception of colour in mankind. This theory, first proposed by Young, and adopted by Helmholtz and Schultze, supposes that each spot on the retina contains a number of nerve-terminals, each of which is capable of excitation by one colour only, or, in other words, by æther-waves having a determinate rate of rapidity, and no others. By these terminals, a compound æther-wave would be decomposed into its constituent elements, which would arouse sensation in the corresponding nerve-fibres. It is usual to assume three such primary percipient elements, adapted respectively to the stimulation of red, green, and violet light. All other colours would be represented in consciousness by combinations of these in varying degrees of intensity. It is probable, however, that the real number of separate kinds of terminal is vastly greater. Moreover, considerable doubt hangs over the mode of excitation in the cones themselves, each of which is supplied with a large number of ultimate nerve-fibres (axis cylinders), and is therefore in all pro-

[1] See papers by Dr. Aug. Charpentier, "De la Vision avec les Différentes Parties de la Rétine," in Archives de Physiologie, No. 6, 1877, p. 924; and by Landolt and Charpentier, Comptes Rendus, 18th February 1878, p. 495.

bability a compound, not a simple, percipient element. It has lately been suggested that each cone may be provided with separate portions for the perception of the various elementary colours; and these portions may be divided either longitudinally or transversely. But the whole subject is still wrapped in the greatest obscurity, viewed from the physiological side; and it is only by approaching it psychologically that we can hope to arrive for the present at any decisive result.

CHAPTER IV.

INSECTS AND FLOWERS.

Now that we have examined a few amongst the various modes by which waves of æther, as a whole, may affect the sensory system of animals, let us turn at last to our more proper subject, and inquire by what steps the different kinds of æther-waves came to be differentially cognised in consciousness as red, green, yellow, or blue. We find ourselves now face to face with the ultimate problem which we have determined, if possible, to solve in the present volume. We must see what immediate advantage animals could gain from the possession of a nervous structure capable of that differential stimulation by the diverse varieties of light which we know subjectively as the colour-sense.

There are two great classes of animals amongst which the existence of a colour-sense is most certain, and its reactions upon the external world most conspicuous. These are the articulates and the vertebrates. The first class affords us the beautiful butterflies, beetles, and crustaceans; the second gives us the golden coats of fish and lizards, the exquisite plumage of tropical birds, and the striped or dappled skins of the fur-bearing mammals. To the first we owe the existence of flowers, to the second we must refer the colours of all bright-hued seeds and fruits. Accordingly, for every practical purpose, we may narrow down our inquiry to the consideration of these two great classes; and amongst the articulates, the division which most obviously calls for special notice is that of insects. So our first task must be to account for the existence of a colour-sense in the insect eye, and to discover what were the objects for the sake of which this mode of perception was developed?

Clearly the inorganic world does not offer us any chance of a satisfactory solution. The dull clay and grey-blue rocks have none of the brilliancy and purity which is needed as the groundwork for a first differential stimulation. Such complex wave-systems as they reflect would be too mixed, too confused, too indefinite, too variable to afford any means of clear recognition by an early half-developed sense. And even if it were otherwise, the insect does not need to trouble itself about the chemical or mineralogical character of the ground upon which it crawls or alights. A few rare inorganic bodies do indeed possess the requisite simplicity and richness for the supposed first stimulus, as we see in the ruby, the emerald, the sapphire, and the topaz; nay, some much commoner substances, such as red sandstone and blue granite, are endowed with a moderately bright and pure colour. All these bodies, however, lie open to the fatal objection that they do not in any way contribute to the welfare of the insect or animal which looks upon them. A sense highly developed by other means may (as we see in the savage or barbarous love for precious stones) be agreeably exercised upon such objects; but in order to give that sense its first start, some direct advantage must be secured by the new mode of discrimination, either in the pursuit of food, the search for mates, or the avoidance of enemies. No faculty can possibly be originally developed for the sake of mere useless exercise upon unessential acts; although, as we shall see when we come to examine the æsthetic value of colour, each faculty, when once fully established, admits of immense pleasurable extension by being directed towards such secondary ends.

The same line of argument applies to those occasional displays of colour which are due to transient effects of sunlight, through the medium of a refractive vapour. Long before the first insect vision learnt to discriminate between red, yellow, and blue, the various rays which we call by those names poured down unnoticed upon the primeval world. Then, as now, the rainbow scattered ten thousand colours upon the dull grey clouds, but no eye drank in the diverse stimulation from its gorgeous undertones of melting orange and exquisite green. Then, as now, the sunset crimsoned the west with dying glory, and bathed the horizon in floods of golden light, but no living thing beheld its loveliness or revelled in its changeful wealth. Such distant and exceptional displays could have little or no effect upon the life of tiny creatures that picked out in fear and trembling a precarious livelihood amid palæozoic forest shades. Even our own nearest mammalian relatives seem totally unconcerned with regard to the magnificent pictures which are spread nightly before their eyes in tropical plains. Indeed, the savage members of our own race, or even the stolid peasantry of European countries, appear to notice such useless phenomena with little curiosity or admiration. Part of our business in this work will be to trace out the slow steps by which the love of bright-coloured food led on to the choice of bright-coloured mates; and how this again brought about a liking for bright colours in general, which shows itself in the savage predilection for brilliant dyes and glistening pebbles; till at last the whole long series culminates in that intense and unselfish enjoyment of rich and pure tints which makes civilised man linger so lovingly over the hues of sunset and the myriad shades of autumn. But if even the lower types of humanity are little stirred by such glowing sights, how could we expect the humble insect to have developed a new sense for their perception? Here, as elsewhere, the disinterested affection can only be reached by many previous steps of utilitarian progress.

It is to the organic world, then, the insect's practical world of food and prey, that we must look for the first development of the colour-sense. In the origin of flowers we shall find also the origin of the insect's perception; and though the inquiry will seem at first to lead us rather far afield from our proper path, I think we cannot do better than steadily set to work at unravelling the tangled thread of their mutual influence. In order to do so effectively we must first glance at the condition of the world before flowers, fruit, or colour-sense had yet begun the first stages of their reciprocal existence.

Brongniart long ago pointed out that the periods of geological vegetation fall into three main divisions, which he called the reigns of acrogens, of gymnosperms, and of angiosperms. Acrogens are plants like ferns and mosses, which bear no fruits or flowers, but produce their young by means of spores. Gymnosperms are plants like pines and firs, which have their blossoms and seeds in dry scaly cones. Angiosperms are true flowering plants, often bearing bright bells or brilliant clusters of bloom, and always having their seeds enclosed in some more or less conspicuous form of enveloping fruit. These three kinds of plants succeeded each other through the geological series in the order here assigned to them—members of every class still surviving on our earth, but outnumbered and overlived, as a rule, by those of the newer and more successful classes.

For our present purpose, however, we might say more truly that the great epochs of vegetal life naturally fall under three similar heads—the reign of flowerless plants, the reign of wind-fertilised flowering plants, and the reign of insect-fertilised flowering plants.[1] These three heads correspond in the main with Brongniart's divisions, but they serve to bring more clearly into prominence the salient functional facts with which we are here especially concerned.

Flowerless plants, or cryptogams, are those which have

[1] See an excellent article on "The Geological Antiquity of Insects and Flowers," by Mr. J. E. Taylor, F.G.S., in the "Popular Science Review" for January 1878.

no conspicuous organs for the production of seeds or fruits. Their chief varieties are known to all as fungi, sea-weeds, mosses, and ferns. Flowering plants, or phanerogams, are those which possess more or less conspicuous organs for the production of seeds and fruits. They may be divided, not structurally but functionally, into two great sub-classes—the anemophilons and the entomophilons. Anemophilous plants include all species in which the pollen of the male flower is wafted to the stigma of the female flower by means of the wind. Entomophilous plants include all species in which the pollen is carried to the stigma upon the head, legs, or bodies of insects. Each of these classes possesses numerous species in which various modifications have been produced to aid fertilisation by the appropriate means. Some of these modifications we shall examine as we proceed; for others, the inquirer must be referred to special works upon the subject.[1]

In the great forests of the Carboniferous era few or no flowers diversified the unbroken green of the primeval world. Almost all the plants which raised their heads above the dark mould of those forgotten deltas were acrogens or other cryptogams. Like the ferns and mosses of our own epoch, they reproduced their kind, not by means of flowers and seeds, but by inconspicuous little spores, each of which rooted itself on the ground independently, and grew into a young plant. Many of them resembled the bristling horse-tails of modern waste lands, magnified a hundred-fold, so as to present the appearance of huge jointed trees, to which geologists have given the name of calamites. Others were rather the gigantic analogues of our creeping club-mosses, with monstrous thickened stalks, clad in a sort of plated armour, and known to science as *sigillariæ*, *lepidodendra*, and *haloniæ*. Yet others, again, grew like the tree-ferns of our latter-day tropics, with

[1] See, in particular, Mr. Darwin on the "Fertilisation of Orchids," Sir John Lubbock on "British Wild Flowers in their Relation to Insects," and the works of Sprengel, Delpino, and H. Müller.

graceful waving fronds, whose delicate outline is still faithfully preserved on the flat surface of many a coal-seam. But amongst them all not a single bright blossom anywhere displayed its crimson petals or its golden bells; not a single fruit gleamed red or orange among the embowering foliage. Green, and green, and green once more; wherever the eye of an imaginary visitor could turn, it would have rested on one unbroken sea of glistening verdure.

A few phanerogams there were, it is true, among this mass of cryptogamic vegetation, but they belonged entirely to the pine and cycad families, which grow their seed in hard scaly cones, and would never be included amongst the flowering plants by any but a technical botanist. Moreover, as their blossoms are green when young and brown when ripe, they would form little or no exception to the prevailing tints of the palæozoic world. Even if a few primitive grasses of some archaic form intermingled, as is possible, with the mosses and liverworts which carpeted the ground beneath the conifers, the tree-ferns, and the titanic lycopodites, yet these themselves would bear their seed in green panicles on a waving stem, and would still add no new element of colour to the one monotonous field. Not a trace of any vegetal organism has yet been discovered in the primary rocks to which we can even conjecturally attribute a possible tinge of red or orange, blue or yellow, in the form of flowers or fruit.

Equally unvaried, no doubt, was the hue of the articulate creatures which fed amid those green jungles of tangled fern and club-moss. A few scorpion-like insects, an occasional cockroach, beetle, or other uncanny creeping thing, may still be detected in the *débris* of a forgotten world; but no trace of a bee, a moth, or a joyous butterfly can be discovered in these earliest ages of animal life. Scarlet berry and crimson blossom, gorgeous bird and painted insect, were all equally absent from the unvaried panorama of green overhead and brown beneath.

Such, we may suppose, was the general appearance of our earth's surface before the colour-sense had given rise to all the diverse wealth of hues which gladden the woodland and the meadow for modern eyes. First to be developed among the bright-coloured objects of the newer era were the brilliant whorls of abortive leaves which ordinary people know as flowers. Their origin affords us the key to all the subsequent evolution both of coloured organisms and of the sense whereby they are perceived.

The transition from the wholly green and spore-bearing cryptogams to the bright hues of entomophilous blossoms was through the intermediate stage of anemophilous plants. Already, in the Carboniferous era of the palæozoic world, we have seen that these organisms had begun to exist. The causes which led to their development throw so much light upon the subsequent evolution of insect-fertilised species, that we must pause for a moment to examine the history of their first appearance.

Every individual cryptogamic plant produces spores or young individuals by its own unaided generative power. It needs no co-operation from a partner of a different sex to fertilise the embryo germs which it puts forth. True, a male and a female element may always be discovered within the plant itself; but their occurrence does not militate against the general statement that cryptogamic reproduction is essentially hermaphrodite or non-sexual in its character. For real sexual generation consists fundamentally in this, that two independent parents combine to produce a brood of young, partaking equally, on the average, of the idiosyncrasies of each. Now, Mr. Darwin has shown[1] that whenever an organism is the result of interaction between two anterior organisms, it possesses a vigour, a plasticity, and a hardiness which enable it to thrive far more easily than any similar organism resulting from the generative action of a single parent. Our great teacher has proved that self-fertilised flowers produce

[1] On "Cross-Fertilisation," *passim.*

relatively weak, puny, and unhealthy young; while cross-fertilised flowers produce relatively strong, hearty, and vigorous young. The general principle upon which this effect depends has been exposed, with his usual luminous insight, by Mr. Herbert Spencer;[1] but unfortunately its explanation would involve too many wide questions of biological theory for reproduction here.

If, then, by any special combination of circumstances, it should happen at any time that certain plants acquired the habit of fertilising the female element in one individual by the male element of another, it would necessarily result that such plants would produce exceptionally healthy young, and so gain unusual advantages for their descendants in the struggle for life. And this is exactly the case with flowering as opposed to flowerless plants. While the latter still continue to fertilise themselves in every instance, the former possess a special set of male and female organs, often situated on different individuals, and almost always so disposed that the pollen of any particular flower is specially prevented from quickening the ovules of its own pistil. Indeed, the very effect which Mr. Darwin's experiments show us on a small scale, nature herself here shows us on a large scale; for when once the flowering plants had been introduced into the world, their superior vitality gave them such an increased chance in the struggle for life that they have now overrun the whole earth, and almost lived down the very memory of their cryptogamic predecessors, whose huge forms diversified the landscape of a palæozoic wild. Step by step, throughout the secondary and tertiary periods, we find the acrogens decreasing in number of species, in frequency of individuals, in size and height; while step by step we find the flowering plants dispossessing them over the whole world, and growing into more and more varied forms, with ever-increasing numbers and ever-widening girth; until at last forest trees, and herbs, and grasses cover the face of hill,

[1] Principles of Biology, vol. i. chap. x.

and plain, and valley; while only in a few tropical jungles, or a stray patch of neglected English warren, do we still discover the degenerate descendants of those giant tree-ferns and horse-tails which flourished without a rival over vast continents during the earlier ages of vegetal life.

Among these flowering plants, which thus substituted the sexual for the hermaphrodite method of reproduction, the anemophilous or wind-fertilised division was the first to appear. The ever-moving currents of air naturally offer the earliest and simplest agency for the dispersion and transference of pollen from the stamens of one blossom to the pistil of another. Accordingly, we find the pines and cycads, both of which bear their flowers in the form of cones or other unnoticeable bunches of floral organs, as the earliest representatives of flowering plants. After them, in geological order, come the monocotyledons, represented by grasses, rushes, and other spiky species, whose blossoms assume the shape of green panicles or waving plumes; while, last of all, come the dicotyledons, whose anemophilous varieties are usually distinguished by those pretty hanging clusters of stamens or pistils which we know as catkins. Now, in all these cases, the mature male organs, covered with the fertilising pollen, necessarily protrude from the scales, sheathes, or glumes which guard their younger stage, and offer large surfaces to the wind, whose aid they require in the dispersion of their stores. Similarly, the pistils or female organs must possess spreading and feathery stigmatic processes, wherewith to catch any stray grains of pollen which the unconscious wind may waft to their neighbourhood. Hence these blossoms consist usually of bundles or masses of male and female organs, hanging out in such a way as to secure the favour of every passing breeze; but they never possess those bright whorls of coloured leaves which make up the popular idea of a flower. The latter notion is mainly based upon the peculiar structure of entomophilous plants.

As wind-fertilised flowers can only hope that a small fraction of their pollen will reach the stigmatic surface of their brides, and there be drunk in to fertilise the embryo within, they must needs produce enormous quantities of useless material, to be dissipated by the storm in every direction. The amount of pollen thus wasted is often incredibly great. The floor of a pine forest during the flowering season frequently lies thickly covered with the rich yellow dust that cost so much useless energy to the parent plant. Occasionally even showers of pollen grains have been noted in the neighbourhood of great forests or of fields thickly sown with anemophilous species. At Mumbles, near Swansea, a yellow-coloured rain fell in 1850, and left large spots of ochre-like matter, which proved on close examination to consist of willow-pollen.[1] Similar showers, produced by the Canadian conifers, have often been observed along the shore of the great lakes, and others have taken place in Zurich, in Brunswick, and in Inverness-shire. Of course, the loss of energy which this waste expenditure involves for the parent plant must necessarily be very great; and any change in its circumstances which produced a more economical mode of applying the pollen to the pistil would naturally result in a saving of material, and so give the plants in which it occurred a fresh advantage over their less fortunate compeers. Such a change we see in the utilisation of insect agency by the entomophilous plants.

Even as early as the Carboniferous period we find traces of terrestrial articulates which might have sought their food among the few coniferous blossoms of that mainly flowerless world. Most of the plants about them were hard, scaly, innutritious acrogens, whose stem and leaves contained large quantities of silica, as we still see to be the case in the horse-tail family, their nearest modern allies. But the stray flowering species which grew at rare intervals in the midst of the calamites and lepido-

[1] Balfour's Class-Book of Botany, p. 562.

dendra must have offered special attractions to insects (or their undifferentiated ancestors) in the shape of soft, edible, nutritious pollen. And as the insects travelled from one flower to another, carrying on their legs or heads the fertilising powder, they would supply the plant with a cheaper and more certain means of impregnation than that afforded by the wasteful wind. Accordingly, any plants which offered special advantages to insects, in the shape of pollen, sweet juices, or soft edible matter, would thus obtain an extra chance in the general competition for a share of the earth's surface, and hand down the peculiarity to an ever-increasing brood of descendants. So, when once the entomophilous flora began to exist, it gained ground rapidly on the anemophilous division, as the anemophilous flora had previously gained ground on the flowerless plants, until in our own day the two divisions divide the world between them; while in the future, doubtless, the balance will be still further disturbed in favour of the younger and more vigorous races.[1]

Of course, the change from fertilisation by wind to fertilisation by insects could not be accomplished without many structural modifications, whereby the flower became adapted to the new and more specialised agency thus afforded it. Some of these modifications were concerned with the food offered by the flower to the fertilising insect. At first this food doubtless consisted of pollen alone, but after a time there was added that sweet matter known as sugar or honey, which is contained more or less in most plants, and which is especially developed during the two processes of flowering and fruiting. Now sugar, by its crystalline condition, so rare amongst energy-yield-

[1] The botanical critic need hardly be told that I am here intentionally neglecting the more deep-seated *structural* differences, which depend upon the line of descent, and considering only the superficial *functional* differences, which depend upon adaptive accident. The general reader would only be confused by constant references to the cross-division of monocotyledons and dicotyledons, especially when complicated by the peculiar geological position of the gymnosperms.

ing organic products seems specially adapted for affording pleasurable stimulation to the gustatory nerves of animals;[1] and it has therefore been seized upon by plants in all those cases where the attraction of some animal ally is desirable for their protection or the continuance of their species. Certain plants lay it by in glands upon their stems to allure the harmless ants who protect them from the ravages of their leaf-eating congeners.[2] Others, again, as we shall see in a later chapter, collect it in the pulpy covering of their seed-vessels, and thus induce parrots, pigeons, or monkeys to devour and distribute the indigestible kernel. Yet others distil it in the recesses of their blossoms, and so tempt the bee, the butterfly, or the humming-bird to rifle their labyrinthine storehouses, and unconsciously aid in the impregnation of their embryos. The honey thus elaborated by the flower has become at last the main ultimate attraction for all fertilising insects, whose most specialised forms we find in the common hive-bees of domestic economy.

A second class of modifications is connected with the shape of the flower. Most entomophilous blossoms possess, in addition to the pistil and the stamens, two other whorls of floral leaves—the corolla and the calyx. In the simplest form of flower, these whorls consist of separate pieces (petals and sepals), as we see in the buttercup or the dog-rose. But in certain more specialised flowers the long-continued action of the insect-fertilisers has unconsciously selected those blossoms which most easily suited themselves to the form of their visitor, and has thus produced a united corolla, all whose petals are joined into a regular tube or cup, as we see in the Canterbury bell, the convolvulus, and the lily of the valley. A number of these tubular flowers united form the head of the daisy, the marigold, and the sunflower. In still more specialised cases the cup becomes irregularly lobed, so as to suit still

[1] See my "Physiological Æsthetics," p. 68.

[2] F. Müller in "Nature," June 7, 1877.

more closely the shape of its insect friend—a change whose first steps we see in honeysuckle and foxglove, while its completed stage is shown in mint, dead-nettle, snapdragon, lobelia, and orchids. All these varieties of entomophilous flowers we shall have to examine at greater length hereafter.

But the third class of modifications, the important class for our present subject, is that which refers to the colouring of flowers. By far the most conspicuous difference between entomophilous and anemophilous blossoms is the difference of colour. While wind-fertilised plants have seldom more than a few brownish scales or tiny green sepals around their fructifying organs, insect-fertilised plants are almost always distinguished by the growth of large, brilliantly-coloured petals outside the essential whorls, which act as guides and allurements to the eyes of bees or butterflies. These wide, expanded, and costly structures have absolutely no other purpose in the vegetal economy than that of attracting the fertilising agents; and they afford by themselves a strong presumption of developed colour-sense in the creatures for whose guidance they have been slowly evolved. Let us see by what steps they can gradually have reached their present conspicuous dimensions.

We will suppose that some of the flowering plants in the early ages of the world showed some slight tendency to develop the various attractive structures which we now observe in their completed form. They offered to insects the soft and nourishing pollen, and perhaps, too, small quantities of stimulating saccharine matter. Such saccharine matter we know is always evolved during the opening of flowers, at least in small amounts, for the nurture of the blossom itself; and there is nothing extravagant in the supposition that occasional individuals might produce it in more than the average quantity, and so might attract more than the average share of insect attention. In like manner they may possibly have shown a tendency to develop bright-coloured leaves around their essential organs; and if the eyes of insects were capable of distinguishing these bright colours, in however imperfect a degree, it would naturally follow that the hues would go on deepening from generation to generation among the plants, while the perception would go on sharpening itself from generation to generation among the insects. For while the flowers which thus become more and more readily distinguishable by their fertilisers would thereby better secure the chance of descendants, the insects which most readily distinguished flowers would thereby secure for themselves the greatest amount of the available food-stores. So that, supposing such a tendency once set up on either side, we can see every reason why it should ultimately develop to its present noticeable extent.

This, however, is mere *a priori* hypothesis. The experimental philosopher will ask at once whether we have any grounds for believing that the tendency in point would ever be set up. I think we have such grounds in abundance, and although the question involves a little closer application and more technical considerations than any we have yet encountered, I shall ask the reader patiently to follow me through the exposition, because it really encloses the whole fundamental basis of the developed colour-sense in every terrestrial animal. The point which we have first to consider is this: Did flowers show an original tendency to the production of coloured adjuncts prior to the selective action of insects? And when we have answered that question we must proceed to the second one: Did insects possess any tendency vaguely to discriminate colours apart from the reactive influence of entomophilous flowers?

The solar radiations, falling upon the green portions of plants, are the sole ultimate source of all the energy existing in the animal or vegetal organism. Under their influence, the plant separates carbon and hydrogen from the oxygen with which they were originally combined, stores them up in some part of its own tissues, and turns the free oxygen adrift upon the atmosphere around. In this process, the kinetic or active energy of the solar undulations has assumed the potential or dormant form. The potential energy thus laid up is associated with the carbon and hydrogen of the plant on the one hand, and with the free oxygen of the atmosphere on the other. Whenever they may recombine, the dormant energy will assume once more the active form, and be yielded up in the shape of mechanical motion, heat, or light.

This reconversion of contained energy into its mobile mode may be brought about in many ways. Sometimes the plant may be cut down and burnt, as we all see in wood-fires, and then the energy will be given out rapidly as heat and light, while part of it will also go off as motion of the surrounding air. Sometimes the plant may fall as it lies, be changed into peat or coal, and finally burnt, like the wood, in a human grate, with the same concomitant phenomena as in the first case. Sometimes, too, these same materials—wood, coal, peat—may be used to feed a steam-engine, and mainly converted into visible movements of the locomotive or its parts, which are finally dissipated by friction into the circumambient æther. In yet other cases, the plant may be eaten by an animal, and then its elements will recombine within his body with the free oxygen supplied by his lungs or gills, and will give off heat and motion, less conspicuously perhaps, but quite as truly as in the engine. There remains, however, another instance, fully as common as these, yet far less generally observed—the instance in which the elements recombine in the tissues of the living plant, and yield up their dormant energies in producing growth, development, and rearrangement of its parts. This metamorphosis of energy (known as *Stoffwechsel* or *Metastasis*) actually takes place in every active portion of a plant which does not itself assimilate nutritive material from the surrounding air. And all such parts of plants may be considered as carrying on essentially animal functions—that is to say, functions by which potential energy becomes kinetic, oxygen unites with carbon to form carbonic anhydride, heat is evolved, and motion is given out.

The most noticeable cases of such quasi-animal processes may be seen in the germination of seeds, the growth of bulbs and tubers, the unfolding of flowers, and the ripening of fruits. In fact, every growing and active part of a plant, unless it be itself assimilating kinetic energy from solar undulations, must necessarily be using up energies assimilated elsewhere. Otherwise, it would be manufacturing new energies for itself out of nothing, which we know to be impossible, and inconceivable as a direct contravention of all physical and mental laws.

Now, the active agent of deoxidation in ordinary plants is that peculiar compound substance known as chlorophyll, the pigment which gives a green colour to healthy leaves. Hence all the active organs of plants are usually green in hue, because the chlorophyll is seen through the transparent cell-walls of the epidermis. But there are reasons for believing that wherever the reverse process of metastasis is taking place, other bodies are frequently formed, which reflect the light in slightly different manners, and so give rise to tints of red, orange, yellow, pink, mauve, purple, or blue. We will examine the evidence in order, and see whether we can gather from it any inference as to the origin of coloured flowers.[1]

In the first place, even in active leaves, the presence of green chlorophyll is often masked by the occurrence of other pigments, which give the foliage a tinge of brown, russet, scarlet, or golden yellow. Cases of this sort are

[1] In the succeeding argument I have neglected for a while the difficult chemical question of the relations between *chlorophyll*, *xanthophyll*, *erythrophyll*, and the other colouring matters of plants (see Sorby in Proc. Royal Soc., vol. xv. p. 433, and vol. xxi. p. 442; also in the English version of Sach's Text-Book of Botany, p. 686), because the results hitherto reached are still somewhat indefinite, and because the consideration of the chemical changes involved is better relegated to the end of the physical and physiological inquiry, upon which we must now enter. A fuller statement on this point will be found on a later page.

commonly known in the copper beech, the red cabbage, and the various species of purple coleus, crimson-hearted caladium, pink dracæna, or pale mauve begonia. Here the colouring matter doubtless belongs to some one among the many by-products of vegetal physiology, which must necessarily occur from time to time in one part or another as the results of assimilative or metastatic changes. But in the more noticeable cases of coloured juices or pigments, other than green, we shall find that the special colouring matter is almost always more or less connected with those portions of the plant where energy is being liberated, and where accordingly oxidation is necessarily taking place.[1]

The only class of plants in which green rarely—we might almost say never—occurs, is that of fungi. But fungi differ from all other plants (except a few parasites and saprophytes) and agree with animals in this, that they derive their energies not directly from solar undulations, but from organised matter already contained in the soil or matrix on which they grow. And there is something in the vivid orange, yellow, lilac, and crimson of their hues, as well as in the pasty whiteness of their common tissues, which strikingly recalls the possibly adventitious colouring of the lower animal forms, such as sea-anemones, starfish, and medusæ. This analogy, as we shall note hereafter, is not without a deep significance for our present purpose.[2]

When, however, we go on to those plants which have normally green leaves, we see a like result. In the first place, dying leaves, as we all know, assume the most bril-

[1] See on the whole process of metastasis, Sach's "Text-Book of Botany," p. 626, *seq.* It is to be regretted that the author of this otherwise lucid and valuable book has not brought more prominently into notice the question of the energies involved, and the transformations which they undergo, by oxidation, &c. A botanical work which should extend to the plant organism the same strictly physical treatment as Hermann's "Physiology" applies to the animal organism is still a desideratum.

[2] See also Sorby, in Proc. Roy. Soc., vol. xxi. pp. 475-480.

liant tints of red, yellow, orange, and brown. Even in our own damp and uncertain climate, the Virginia creeper glows with the richest crimson, while the forest trees shade off into delicate tones of golden gloss and occasional flashes of deep scarlet light. But in American woodlands these displays assume grander dimensions and more glorious beauties, forming perhaps the most magnificent fields of gorgeous colour in the whole organic world. Now, Macaire-Princep has shown,[1] that as leaves begin to turn yellow they give up the function of deoxidation, while a reverse process at once sets in. Mr. Sorby traces the gradual loss of vitality in the fading leaf from bright green through greenish-brown, red, scarlet, and orange-brown to the final dull and dingy hue of the dry leaf.[2] That this change results from some degradation of energy, in whatever component of the leaf it may take place, is beyond all doubt.[3]

Any injury to leaves causes similar effects, whether due to disease, external impact, or the attacks of insects. Gall-nuts and rose-blights have generally an outer coating of small reddish excrescences, while feeble plants produce yellow-spotted or pink-speckled leaves. Here, too, oxidation, or some other de-energising action, is most probably the cause of the change observed.

Leaves which have given up their natural functions frequently assume bright hues. Thus the pitchers of the side-saddle flower (*Sarracenia rubra*) have purple tips.[4] Those of the pitcher-plant (*Nepenthe*) are "tinted and mottled with red and purple."[5] The leaves of the curious insectivorous plants, with whose habits Mr. Darwin has made us so familiar, are apt to be speckled with similar hues, especially in the active portions, which show, by

[1] Mém. de la Société Phys. et d'Hist. Nat. de Genève, iv. 43.

[2] *Ubi supra*, and "Nature," January 19, 1871.

[3] Quarterly Journal of Science, 1871, p. 64, and 1873, p. 451.

[4] See the figure in Sir W. Hooker's "Flora Exotica," pl. 13.

[5] Wallace, "Malay Archipelago," p. 81.

their movements and secretions, some approach to animal functions. The common English sundew (*Drosera rotundifolia*), which may be found in all boggy or peaty places, has bright red glands scattered over its leaves. The Venus fly-trap (*Dionæa muscipula*) is "thickly covered with minute glands of a reddish or purplish colour," while the spikes which close upon the insect prey have small projections described as "reddish-brown or orange." Like organs in *Drosophyllum lusitanicum* are bright pink, and in *Pinguicula lusitanica* purple.[1] Our own common butterwort and saxifrage, which share to a less extent the same peculiarity, have also slightly reddish or yellowish foliage.

Parasites which live upon the energetic matter stored up by other plants fall obviously under the same class. Their whole existence consists in a continuous metastasis, that is to say, in the expenditure and liberation of previously accumulated nutriment, under the influence of oxidation. The common European broom-rapes (*Orobanche*) have no green leaves, but merely pink, purple, brown, yellow, blue, or rose-coloured scales and flowers. *Cytinus hypocistis*, which grows parasitically on the roots of the *Cistus*, has a bright orange stem and leaves. The common English dodder is noticeable for its pretty twining red filaments, while its Indian congeners display brilliant hanging masses of golden threads.[2] In fact, almost all true and perfect parasites are remarkable for the absence of green and the presence of other bright hues. Of course, many plants usually included under that name, like the mistletoe family, have foliage of the ordinary colour; but these are in reality only half-parasitical, a kind of stepping-stone between the epiphytic plants (orchids and bromelias) and the thorough-going parasites, such as *Rafflesia*. To the very end, indeed, the degraded leaves

[1] For *Drosera*, see Darwin, "Insectivorous Plants,' or any English moor; for *Dionæa*, *ibid.*, p. 287; for *Drosophyllum*, p. 333; and for *Pinguicula*, p. 391.

[2] Hooker, Himalayan Journal, pp. 28, 38.

or scales of flowering plants contain some traces of chlorophyll,[1] which, however, like the leaves themselves, must be regarded as mere obsolescent relics of their earlier state. It should also be noticed in passing, that many parasites, like *Rafflesia* and *Hydnora,* have exceptionally large and brilliant flowers. The blossom of *R. Arnoldi* sometimes measures three feet in diameter.

Still more noticeable in hue are the plants known as saprophytes, which live like fungi on the decaying matter contained in dead foliage or other organic remains. These, too, have no real assimilative leaves, while their functions are purely animal, consisting in the absorption of oxygen and the expenditure of previously accumulated energies. The Indian-pipe plant of Canada (*Monotropa uniflora*) has a pure white scaly stem and flower,[2] exactly resembling a fungus to the untrained eye; it grows under the shade of pine forests, amid the rich *débris* of their pollen and their fallen foliage. The beautiful *Neottia speciosa* has a scape and rudimentary leaves of bright scarlet. *Corallorhiza* and many other saprophytes are equally remarkable for their exquisitely coloured scales. It is true that several, if not all, of these plants contain small quantities of chlorophyll or xanthophyll;[3] but here again, we must regard the pigment as a mere remnant of earlier ancestors; while the plant, as a whole, mainly consists of metastatic materials, or, in other words, of oxidation products.

The resemblance which both parasites and saprophytes bear to fungi is certainly remarkable when we remember their close community of nature and function. All alike live upon previously organised material, and all have the same flabby, succulent, pulpy appearance. The Indian-pipe plant is always described by Canadian farmers as "a kind of toadstool;" the *Rafflesia* is noted for its fungoid

[1] Wiesner, Botan. Zeitung, 1871, p. 37, quoted in Sachs, 643.

[2] For our present purpose, white, as differing from green, must, of course, be accounted a colour.

[3] Oscar Drude, "Biologie von Monotropa," &c., Göttingen, 1873.

look and animal odour; the *Cytinus* exhales a meaty flavour; and the *Cynomorium coccineum* is known to druggists by the technical name of *Fungus melitensis* or Malta mushroom. Putting these facts by the side of their very similar colouration, we are not unnaturally led to expect some causal connection such as that of which we are now in search. Let us pass on to other coloured portions of ordinary plants, which may throw a little more light upon the question at issue.

Buds contain energetic material, stored up by the plant during the preceding season, and expended, presumably, by union with oxygen, during the spring. The sprouting buds of the hawthorn and of many other plants present exquisite tints of pink and mauve. The bulbils of the tiger-lily are covered by purple scales. The various devices by which plants lay by nutriment during one season for their growth in the next are known as bulbs, tubers, corms, or rhizomes. All of these are apt to produce young sprouts of dainty colouring and bright hue. The growing sprays of the potato, when kept carefully from the light, exhibit distinct tinges of pink, blue, violet, and yellow. Asparagus shoots and blanched sea-kale have scales or leaves of mauve, lilac, and greenish brown. Almost all bulbs, on first producing leaves, show very decided colours, which change to green under the action of light. Beet-root, permitted to sprout in the dark, sends up beautiful bunches of deep crimson foliage. Carrots, under like circumstances, put forth golden sprays, varying from light primrose to bright orange. Sprouting peonies are of a full dark red. Rhubarb has rosy stems and pink or yellow leaves. In many of these cases, the colour is most conspicuous in the thin laminated portion of the young leaves, which offer the best medium for the display of delicate pigments. In every case, exposure to the sunlight brings about reversion to the original assimilative function, and results in the final triumph of green chlorophyll.

The young shoots at the end of branches are in the same position, as regards energy, with the sprouts which arise from bulbs or tubers. They cannot yet feed themselves, but they are nourished by energetic materials from the older leaves, whose carbon combines with oxygen in their tissues to yield the energy whereby their growth is carried on. Now the bright tints of these young shoots are very noticeable (as may be especially observed in the fuchsia, the hawthorn, and the rose-apple), and they can be skilfully arranged in such combinations as to produce a visible effect not at all unlike that of flowers.

If we compare these various cases with those of bright-hued entomophilous blossoms and brilliant fruits, we shall find that they have all one quality in common—they occur in parts which are expenders, not accumulators, of energy. Hence we are led to suppose that those portions of plants which subsist upon previous accumulations are apt to assume bright hues of different sorts. To what can we attribute the tendency which we thus observe? Can we give any *causal* formula for the *empirical* generalisation at which we have now arrived? I think we can, and in the following manner:—

Chlorophyll, the active deoxidising principle, has a definite composition, which enables it to carry on its proper functions, and a definite mode of reflecting light, which we call green. How far its greenness is bound up with its other physical properties we cannot say. Perhaps, as has been objected, it might equally well perform its physiological purpose were it red or yellow. But more probably its special reaction upon light is intimately connected with its special reaction upon carbonic anhydride under the influence of light. However this may be, at least we know that active chlorophyll is always green; and the more active, the brighter its hue, as Mr. Sorby has abundantly shown. Hence, every part of a plant which performs deoxidising functions has necessarily a green pigment for its foundation. The greenness may indeed be masked by other dyes (perhaps themselves the products of oxidation), as in cell-sap or epidermis, but in the actual active principle itself, greenness is apparently always present as an essential and inherent property.

So leaves as a rule, where exposed to sunlight, are green, but the remaining portions of the plant do not seem to be bound by such a stringent law of colouration. There is no reason why other colours should not appear in them from time to time, and, if they prove useful, be perpetuated through the action of natural selection. How, then, do they arise?

Colour, we have seen already, is merely the mode in which various bodies react upon light, reflecting or absorbing its constituent elements in varying proportions of their several rays. But there is no property of different bodies more variable in its nature than this particular mode of reaction. The slightest change in the molecular constitution of a substance is apt to be accompanied by considerable changes in its hue. Materials which appear chemically almost identical pass through strange varieties of tint with the greatest readiness. And this is particularly the case with organic matter, which differs from all other matter in the striking effects produced upon its physical constitution by apparently trifling causes. Hence we might naturally expect that very small changes in the constituents or contents of plant tissues would be likely to produce great alterations in their colour. And we find accordingly in all non-active parts of a plant that by-products of various tints do actually occur with considerable frequency: take, for example, the bright hues of many stems, barks, and juices, the red under-side of the *Victoria regia* leaf, the amber nether foliage of the star-apple, and the beautiful scales of the gold and silver ferns.

Whether such colours are *always* due to oxidation, it would be difficult to say; but in a large number of instances it is quite clear that oxidation is going on in the tissues where the colours appear. Obviously, in all cases of metastasis, the recombination of oxygen with the accumulated hydrocarbons is the only source of the energy whereby growth is carried on. Sometimes as much as 40 or even 50 per cent. by weight of the organic matter contained in seeds which germinate in the dark is lost by conversion into carbonic anhydride and water;[1] and somewhat the same change must take place in bulbs, tubers, corms, and rhizomes. Almost all the above-quoted cases fall apparently under a like generalisation. The red colouring matter of persistent winter leaves, as seen in *Sempervivum, Mahonia, Vaccinium,* and *Sedum,* is due to a substance mainly consisting of tannin.[2] Mr. Sorby does not absolutely say that the colours of autumn foliage are due to oxidation, but he refers them on the whole to decreased vitality, absorption of chlorophyll, and similar causes, which bring into prominence various minor principles otherwise unnoticed. Of the lychnoxanthine series he says expressly, "They are probably only products of the oxidisation of chlorophyll, from which they may be prepared artificially." Of the erythrophyll series, on the other hand, he merely observes, "They are usually indicative of low constructive energy." The chrysotannin group, again, "when oxidised, give rise to various brown substances, which are the cause of many of the characteristic tints of autumnal foliage." But with regard to the pigments of entomophilous flowers his language is much more decided in tone. "The coloured substances in the petals are in many cases exactly the same as those in the foliage from which chlorophyll has disappeared; so that the petals are often exactly like leaves which have turned yellow or red in autumn, or the very yellow or red leaves of early spring. . . . The colour of many crimson, pink, and red flowers is due to the development of substances belonging to the erythrophyll group, and not unfrequently to exactly the same kind as that so often found in leaves . . . The facts seem to indicate that these various sub-

[1] Sachs, *ubi supra.* [2] Sachs, 657.

stances may be due to an alteration of the normal constituents of leaves, some being probably formed from chlorophyll, others from the xanthophylls, and perhaps some from other constituents. So far as I have been able to ascertain, *their development seems as if related to extra oxidisation,* modified by light and other varying conditions not yet understood."[1] In like manner Lory found that parasites, as exemplified by broom-rapes, absorbed oxygen and exhaled carbonic anhydride in all stages of growth, whether exposed to the sun or not.[2] So, also, Morot showed that in etiolated plants the coloured portion of the tissues gave out carbonic anhydride, while the green portion gave out oxygen.[3] In short, without going into the lengthy ultimate question—scarcely soluble at present—whether all bright vegetal pigments (except chlorophyll) are themselves actually oxidation products, we may at least affirm that they occur with exceptional frequency in those plants or parts of plants where oxidation is largely taking place. They may be always directly due to the absorption of oxygen, or they may be merely secondary results of that action; but they certainly show a great tendency to present themselves wherever energy is being expended; and that conclusion is quite sufficient for our immediate object.

Here, to guard against an obvious criticism, it should be added that only a tendency, not a universal law, in such a direction is believed to exist. For example, the leaves of the sensitive plant and the *Desmodium,* which exhibit movements far more marked than those of the insectivorous species already noticed, are perfectly green.[4] But the

[1] Proc. Roy. Soc., vol. xxi. p. 478.

[2] Annales des Sciences Nat., 3me Sér. Botanique, viii. 158.

[3] Balfour, Class-Book of Botany, p. 473.

[4] My thanks for calling attention to this exception are due to Mr. Darwin, who kindly favoured me with several valuable critical observations upon the materials for this chapter when in manuscript. Professor Thiselton Dyer also supplied me with many useful notes in connection with this subject, of which I have gladly availed myself. At the same time, I ought to mention that although I have altered much of my original matter in accordance with objections raised by

whole conclusion here suggested amounts in brief to the following principle: Wherever considerable changes occur in the nature of the vegetal tissues or their contents, they are apt to be accompanied by similar changes in the reaction of the tissues upon the incident sunbeams.

Yet it is a noteworthy fact of great importance, as shedding light upon the origin of the colour-sense, that such brilliant tints are everywhere exceptionally common in the organic world. Besides the green of chlorophyll, the orange and scarlet of autumn leaves, or the varied hues of flowers and fruits, we find unusually bright colouring in many parts of animals, especially the very simplest, such as jellyfish and sea-anemones. Although, as we shall observe hereafter, many of these are doubtless due to the selective action of sexual preference, acting through the colour-sense itself, yet in the lowest organisms there is some reason to believe that the purity and splendour of the prevailing hues are only due to the adventitious composition of their molecules. And when we further notice the brightness of mammalian blood, besides the numerous changeful hues of sundry viscera or their contents, we shall probably be willing to allow that organic bodies habitually display pure and gorgeous tints, which the mineral world only shows us in a few rare and exceptional jewels.

Before we proceed, however, to apply these general principles to the genesis of entomophilous flowers, it will be well to glance briefly at a distinction of considerable importance, already hinted at in the preceding paragraph. Colour, as such, cannot of itself subserve any special function except in connection with the animal eye. The hues of all inorganic and of most organic bodies depend entirely upon the fortuitous molecular constitution of the particular body. But when a colour so reflected happens to produce some specific effect upon the eyes of any animal,

these distinguished naturalists, they are not in any way responsible for any of the statements here made, from many of which Professor Dyer, at least, would dissent in the most unequivocal manner.

whose interference is either useful or noxious to the animal or plant reflecting it, then the principle of natural selection will come into play, and the colour, as such, may be said to subserve the special function of attraction or protection, as the case may be. Henceforward, in the present work, a colour which seems simply to depend upon molecular constitution, apart from function to be subserved, will be described as *adventitious;* while a colour which also subserves a special function will be described as *purposive.*

Now all the coloured objects with which we have so far dealt—green leaves, autumn foliage, young shoots, sprouting buds—are purely adventitious in their tints. Flowers, however, which we next approach, are purposive; but, like all other purposive adaptations, they must necessarily have taken their rise in some adventitious circumstance, afterwards increased and developed by selective action.

With such data before us, then, let us proceed to inquire what was the genesis of those bright entomophilous flowers, which present brilliant tints in specialised thin leaves or petals, admirably adapted alike for rapid oxidation, and for the ostentatious display of delicate pigments.

The flower is one of the purely expensive structures which we noticed above as seats of oxidation and liberated energy. The well-known experiments of Saussure, Dutrochet, Vrolik, and De Vriese, detailed in all handbooks of physiological botany, sufficiently prove that during the act of flowering oxygen is consumed, carbonic anhydride evolved, and heat liberated. These experiments have been generally conducted upon various species of Arum, which are insect-fertilised flowers; but similar phenomena have also been observed in the cones of cycads, whose blossoms are strictly anemophilous. Indeed, as the absorption of oxygen is chiefly concerned with the maturation of the pollen, and, to a less extent, of the pistil, it is clear that it can be but little influenced by the nature of the surrounding structures.

Hence we would naturally expect that all floral organs, wind-fertilised or insect-fertilised alike, would show a tendency to the production of bright colours, in accordance with the general principle here laid down. This *a priori* expectation is fully justified by the actual facts.

In the first place, even among flowerless plants, the purely expensive structures employed in the elaboration of young spores are almost always tinged with some other hue than that of the green pigment which distinguishes the active and assimilating leaves. In mosses the graceful little spore-cases, which rise like miniature fruits at the extremity of the tall spiky stems, are usually pink or reddish brown in colour. The beautiful *Splachnum rubrum* of the Canadian forests has a cup of brilliant scarlet, which has led the children who pick it to give it the pretty popular name of red-cap moss. Many lycopodiums produce bright golden fructifications, very conspicuous in the lovely exotic *L. dendroideum.* Ferns generally bear their spores on the under surface of the frond, where their brown or russet colour makes them very noticeable and pretty objects. So that, in spite of their ill-chosen name, the cryptogams themselves exhibit the universal tendency to varied colouration in the reproductive organs.

Next, when we examine the phanerogamous division of plants, we see at once that the actual floral structures themselves are always more or less marked by distinctive colours. The pollen is generally of a rich golden yellow, while the surrounding scales show tints of silvery grey or faint pink. Even among the wind-fertilised blossoms, not a few are thus rendered conspicuous when they hang thickly together in large close-set masses. Many catkins, several grasses, the larch and other conifers, the dock and its congeners, all display blossoms of considerable distinctness, quite uninfluenced by the selection of insects. The inner bracts of the unopened artichoke head are often a brilliant mauve, not less beautiful than that of many flowers. The glumes which surround the floral organs of grasses are ruddy purple. The female flowers of the common hazel are a fine red, as Mr. Darwin reminds me. Evidently we have here a groundwork of differential colouring upon which selection might set to work, and ultimately produce the striking results that we see to-day in every flower-garden.

These, then, are the ultimate elements of our problem. Flowers consist essentially of male and female organs, which really represent aborted leaves, greatly modified for their special function, as Wolff and Goethe long since pointed out. These reproductive organs are situated at the ends of axes, where growth is failing; and Mr. Herbert Spencer observes that such points are just the ones where coloured leaves, as noted above, frequently make their appearance.[1] In anemophilous flowers, as a rule, we find only the two whorls of essential floral organs; but in entomophilous flowers, as a rule, we find two additional whorls, the petals and the sepals, one or both of which are brilliantly coloured, the colouration apparently subserving no other purpose than the attraction of insects who aid in fertilising the flowers. We can hardly resist the inference that the coloured whorls represent an intensification of the natural tint in growing shoots and floral organs, slowly modified by the selective action of the insect eye.

When we look more closely at the nature of showy entomophilous flowers, this conviction becomes greatly strengthened. If colouration depends wholly or in part upon oxidation of previously stored material, it will follow that very large and massive blossoms can only be produced by the aid of considerable prior accumulations in some portion of the parent plant. Now this is exactly what we find to be the case in nature. Most very big flowers

[1] Principles of Biology, ii. 249, where the whole question treated in detail in this chapter has been rapidly but vigorously sketched out in a few pages.

depend for their support upon bulbs, corms, tubers, or other like bulky reservoirs of energetic material. It will be sufficient to mention the cases of the waterlilies, the lotus, the dahlias, the orchids, the iris, the crocus, the gladiolus, the narcissus, the snowdrop, the daffodil, the tulip, the various lilies, the tuberose, the hyacinth, and the meadow-saffron. In many of these plants the handsomest heads of bloom are secured by cutting off the flower-buds for several successive years, and so preventing the expenditure of material until enough has been accumulated for a gorgeous display of blossom. Certain other flowers, again, depend for support upon starch or other nutriment laid by in the fleshy receptacle from which they spring. This is the case with the artichoke, the dandelion, and many of their sister composites. A third class lives upon materials stored up in the woody branches, as in the almonds, flowering cherries, and other trees, which bloom in the spring before the fresh leaves make their appearance. Yet a fourth sort maintain themselves cheaply upon the manufactured juices of other plants, like the leafless parasite, Rafflesia, whose flower measures three feet in diameter, or the pretty little English dodder, whose suckers fasten themselves tightly upon the growing stems of gorse. A great number of the most beautiful exotics are saprophytes, which live entirely upon the decaying vegetable mould in which they are embedded. Indeed, whenever showy flowers, like poppies and convolvulus, grow without the aid of some such accumulated nutriment, it will generally be found that their petals are thin and papery, so that the total cubical content of the flower-bud is really quite inconsiderable. Such plants, in fact, have learnt to make a very great display at very little actual expense.

Furthermore, flowers often exhibit different colours according to the state of oxygenation which their juices have reached, and these differences, as I shall endeavour to show hereafter, bear a definite relation to the various periods of maturity, and the particular insect whose assistance is required. Almost all blossoms in their early stages contain green pigments and perform foliar functions; but as they mature, they gradually assume their proper hues of yellow, blue, or red. "The endochrome of the rudimentary petals," says Mr. Sorby,[1] "approximates in character to that of the leaves; and, during their development, their leaf-like character is gradually lost, and often new colouring matters are formed." The series of changes may be easily followed in a hyacinth, a tulip, or a daffodil; but perhaps the garden hydrangea (*H. hortensis*) offers the best opportunity for watching this interesting phenomenon, because the structures in which the mauve or pink pigment finally appears are exposed to view during the whole process of maturation. Other changes also frequently take place after the flower is fully developed. "*Cheiranthus chamæleo* has at first a whitish flower, then a citron-yellow, then red or slightly violet; the petals of *Stylidium fruticosum* are pale yellow at first, then lightish rose-coloured; the flowers of *Œnothera tetraptera* are first whitish, than rose-coloured or nearly red; the corolla of *Cobœa scandens* is greenish-white the first day, and violet the day following; the flowers of *Hibiscus mutabilis* appear in the morning of a white colour, towards midday they become flesh-coloured, and at night they are red."[2] F. Müller has observed a *Lantana* at Sta. Catherina in Brazil, the flowers of which last three days, "being yellow on the first, orange on the second, purple on the third day;"[3] and his interesting explanation of this peculiarity will find further mention when we come to treat of the parallel adaptation whereby insects have accommodated themselves to the colours of flowers. Indeed, Delpino believes that all such changes of hue are specially intended to inform the fertilising insects of the proper moment for effecting impregnation.

[1] Quarterly Journal of Science, 1873, p. 463.

[2] Balfour, p. 541.

[3] "Nature," November 29, 1877.

We conclude, then, with much probability, that the bright pigments of entomophilous plants are due originally to the natural oxidation taking place in all purely expensive structures, aided by the selective action of insects. It is noteworthy, as proving the functional origin of these pigments, that both great divisions of flowering plants, the monocotyledons and the dicotyledons, have independently hit upon the very same device of coloured leaves for attracting their insect allies. But this could hardly have happened had not some original groundwork existed in the mere fact of oxidation, upon which selective action might be successfully exerted. Still more clear does this argument become when we recollect that in almost every family under these two great divisions, anemophilous and entomophilous genera may be found side by side, thus proving that the device of colour has been independently adopted by different plants, not twice alone, but a thousand times over. Whenever brilliant leaves showed any tendency to appear in the neighbourhood of the floral organs, no matter what the species, genus, family, or class, it would seem that the plant thereby derived such an advantage as to perpetuate the habit in future, under the constant stimulus of over-population and natural selection, resulting in survival of the fittest.

When we pass on to examine the various parts of the flower which may thus become devoted to the attractive function, we find still plainer evidence to the same effect. The essential floral organs themselves, already so conspicuous in the various catkins, may be specially modified for the sake of displaying brilliant pigments. The common meadow rue depends almost entirely for attraction upon these organs. In the family of Mesembryanthemums, the outer stamens become flattened and petaloid, so as to resemble the corolla of ordinary flowers. In the waterlilies, the tendency towards a similar change is always noticeable. Indeed, if one may hazard a guess in so uncertain a question, analogy would rather lead us to suppose that all petals are modified stamens than that the transition has taken place in the opposite direction. However this may be, the corolla, or petaline whorl, forms in most flowers the main attractive organ. Roses, buttercups, violets, bluebells, and primroses may stand as sufficient examples. Next in order comes the calyx, or sepaline whorl, usually a protective organ, but often so modified as to aid in the function of alluring the insect guests. In the fuchsia, the bright sepals make the most striking part of the whole blossom; while in the tulip, crocus, and other brilliant monocotyledonous plants, both sepals and petals are coloured alike, so as to be usually lumped together under the common name of perianth pieces. In the marsh marigold, the marvel of Peru, the purple clematis, and the crimson *Aristolochia cordata*, the petals are wholly wanting, and the calyx alone performs the task of ostentatious chromatic display.

Nor does the process of colouration stop short at the regular floral whorls. The bracts and other secondary adjuncts often aid in the attractive effect. Several euphorbias have separately inconspicuous flowers, enclosed in a common involucre of the most beautiful scarlet hue. *Poinsettia pulcherrima* bears tiny yellow blossoms, which would doubtless fail by themselves to catch even the microscopic eye of a tropical butterfly; but they are surrounded by a thick mass of gorgeous crimson bracts, so strikingly lovely as to ensure for the plant a place in all our great conservatories. The various arums bear their minute flowers on a yellow spadix, about which grows a huge white or purply-green sheath, known as a spathe, whose large size and bright colour makes up for the relative inconspicuousness of the essential organs. In short, whatever part happened to display a tendency towards bright colouration, and thereby attracted the attention of insects, would naturally grow more and more prominent from generation to generation, till it reached the furthest limit of useful expenditure.[1]

That the colour of the flower is a mere intensification of that prevailing in the stem has long since been recognised by painters. In some cases, as in *Peperomia*, the hue of the stem becomes itself very noticeable. In others, as in *Echeveria*, the stalk and bracts are pinkish, gradually growing deeper till we reach the calyx, while the petals themselves appear simply as an intensified form of the surrounding tint. In *Epiphyllums*, the end of the leaf-like peduncle is often bright red like the blossom itself. Amongst English plants, *Echium*, *Sedum*, *Chrysosplenium*, *Rumex*, and many other genera, show like phenomena. And when, as in the parasites and saprophytes, the stem and scales have no special reason for greenness, we find such brilliant examples as *Lastræa*, *Monotropa*, *Neottia*, and *Corallorhiza*, whose rudimentary leaves are quite as beautifully coloured as the flowers themselves.

From whatever point of view we regard the question, then, it seems equally probable that even before insect selection had come into play certain flowers would show a considerable tendency to the production of adventitious colours. Wherever such patches of red or blue shone out among the prevailing green of primitive forests, we may be sure they would act as beacons to the rudimentary eyes of unspecialised insects. At first their colours would doubtless be arranged in very indefinite patches; but as they were gradually selected by their insect visitors, the effects of cross-fertilisation, by weeding out individual peculiarities, would make their shape and hue more and more definite with each new generation. For such definiteness, as we shall observe abundantly hereafter, is a

[1] I was once given a pine-apple in Jamaica by a negro cottager, the crest or empty bracts of which had assumed a bright scarlet hue, like that of so many *Bromeliæ*, while the succulent mass beneath had become dry and shrivelled. If this peculiarity had proved useful to the plant, instead of hurtful, as it really was, it might have originated a permanent variety. The garden cockscomb (*Celosia cristata*) is an instance of such a monstrosity carefully preserved by artificial selection.

mark of contradistinction between adventitious and purposive colouration. Wherever we find a plant, like the common West Indian *Bromelia pinguin*, in which the spathes are coloured brightly but irregularly, the crimson fading off into white or green, we may fairly conclude that the selective process has not yet proceeded very far. But when we get a definite bunch of crimson bracts, as in *Poinsettia pulcherrima*, standing apart as a regular mass from the green foliage below, we may be sure that the selective process has continued for a considerable period of time; while in the three constant coloured leaves which surround the little blossoms of the *Bougainvillea*, we see a still further progress in numerical definiteness. So, too, if we compare the English cuckoo-pint with the Æthiopian lily (*Richardia africana*), or the apple with the orange, we shall see reason to believe that the former cases represent a relatively incomplete, and the latter cases a relatively complete, stage of the differentiating action. And we shall observe hereafter, when we come to examine the origin of bright-coloured fruits, that these structures, which have been developed to suit the eyes of birds and mammals, and are therefore comparatively late in geological time, possess on the whole much less definite colours than entomophilous flowers, which have been developed to suit the eyes of insects, and date far back in geological time.

The first step towards definiteness in colouration is gained by that dwarfing of the internodes which gives the floral whorls their circular appearance. The earliest entomophilous flowers probably belonged to the dicotyledonous group, which now exhibits the highest differentiation of any; but they consisted of separate petals, like the common dog-rose, instead of being tubular or bell-shaped, like the honeysuckle or the campanula.[1] Gradually, however,

[1] J. E. Taylor, F.G.S., "Geological Antiquity of Insects and Flowers," in "Popular Science Review," January 1878. I cannot agree with Mr. Taylor, however, in supposing that entomophilous monocotyledons pre-

the various petals in certain cases became adnate, that is to say, developed together, so as to form a single indented corolla. The former class of flowers are known as *polypetalous*, the other as *gamopetalous*. At a still later date came the irregular flowers, like the labiates and orchids, which are specially adapted to the shapes of insects; while the differentiating process is doubtless still going on under our very eyes whenever a bee visits a blossom in the meadows around us.

Side by side with this differentiation of various flowers went the differentiation of flower-haunting insects. Even in the Carboniferous world some vagrant species of that great class already lived in the hard siliceous underbrush; but Sir John Lubbock believes that Hymenoptera, Hemiptera, and Diptera first came into being during the Cretaceous era; while Lepidoptera, or butterflies, did not appear until the Tertiary times. Beetles first exhibit evident marks of flower-feeding during the Miocene epoch. As for honey-bees, they probably represent the very latest and most highly differentiated members of the whole class, and they could hardly have reached their present form till a very late period. In short, if we look at the correlation of the flowers and the insects, we shall see reason to believe, what is already suspected on purely palæontological grounds, that gamopetalous flowers could not be developed before the rise of specialised insects having a proper proboscis fitted for fertilising their bloom.

Again, the entomophilous monocotyledons are probably far more modern in date than the bright-coloured dicotyledons, and they are also on the whole far more leaflike and less definite. Most of them consist of six perianth pieces, shaped very much like the ordinary leaves, and seldom having any specialised features. Yet, as they found the field already occupied by bright-hued dicotyle-

ceded similar dicotyledons. All the structural indications point in the opposite direction; and the mere fact of the early appearance of liliaceous plants counts for very little, as their earliest species may very well have been anemophilous.

dons, it was necessary, if they would secure the attention of insects, to bid for their favour by very large and showy blossoms. Accordingly, these newest comers amongst the insect-fertilised plants form a large proportion of our choicest garden species. It will suffice merely to enumerate the iris, crocus, narcissus, daffodil, snowdrop, amaryllis, aloe, tulip, tiger-lily, fritillary, crown-imperial, tuberose, hyacinth, star of Bethlehem, meadow-saffron, hellebore, arum, and Æthiopian lily, to show how many of the most brilliant flowers belong to this class. Even here, however, a large number of species have advanced to a high degree of differentiation, due to the agency of insects. While many lilies have six separate perianth pieces, as we see in the tulip and the fritillary, others, like the lily of the valley, have become quite gamopetalous, or, to speak more correctly, the petaline and sepaline whorls have coalesced into a bell-shaped cup. But the orchid family display the most curious adaptations of all, being modified in an infinite variety of ways to suit the insects of their several countries, and presenting the most marvellous tricks of mimicry, mechanical device, and sportive cunning, which at first sight almost compel us to imagine an inherent consciousness guiding the blind course of their strange developments.[1]

It has been remarked, too, that, as a rule, flowers whose forms are highly modified, so as to admit of fertilisation with considerable certainty by a single insect visitor, do not need the same large display of showy corollas as those which trust almost to chance for the conveyance of their pollen to the proper receptacle. Thus Sprengel contrasts the great size and numerous petals of the water lily, whose shape has no special reference to the organs of the fertilising insect, with the little labiates, whose form ensures the due application of the pollen at every visit.[2] So, too, we may compare the common orchid with the fritillary,

[1] See Darwin, "Fertilisation of Orchids," *passim*.

[2] Lubbock, "British Wildflowers, in their Relation to Insects," p. 55.

the lily of the valley with the tulip, and the composites with the rose family. Of course many interfering causes must be understood as putting a limitation upon the truth of this roughly generalised statement. For example, the great tropical butterflies, the larger bees, and the humming-birds, form fertilising agents who naturally demand large masses of colour as an attraction; or, again, the presence of scent, honey, or other special allurements, may make up in particular cases for the lack of bright corollas. Yet, on the whole, it may be said that, other things equal, high modification in form is accompanied by a decreased expenditure on coloured adjuncts.

Nor is it only in the shape and colour of individual flowers that plants vie with one another for the favours of their insect guests. Like varieties are also to be found in the mode of massing the blossoms so as to attract from a great distance the eyes of passing bees or butterflies. We must remember that the facets of the articulate visual organ are not adapted for perceiving small objects except at a comparatively close range.[1] Hence those plants which can group their several blossoms into large and conspicuous bunches may derive special advantages from the extra attractiveness thus attained. Such species as the peony or the tulip bear a single terminal blossom at the end of their stalk. Others, like the pimpernel or the veronica, have a few tiny flowers half hidden at the axes of the leaves. But the hyacinth, the laburnum, and the lilac, group their bloom into large upright or hanging masses; while the cowslip, the carrot, and the calceolaria produce flattened heads which strike the eye from a considerable distance. The dog-rose, with its scattered flowers, does not catch our passing glance so readily as the apple-tree or the may; and the great tropical flowering forest trees may often be discerned by

[1] See Mr. Lowne's paper "On the Modifications of the Simple and Compound Eyes of Insects," read before the Royal Society, March 28, 1878.

human sight at almost incredible distances for the stay-at-home European.

But the composite plants offer by far the most instructive example of the effect produced after many generations of unconscious selection by the visits of insects. The first approach toward their mode of aggregation may be seen in the head of clover, where a number of separate little pea-blossoms are collected into a compact assemblage by the shortening of their several stalks. In the scabious we find the like tendency carried still further by the addition of a broad receptacle and a bunch of surrounding leaves, known as an involucre, which fulfils the protective functions of a calyx for the compound group. The real calyx, however, on each single blossom, still retains its original form, and doubtless assists in the performance of its proper office. But in the true composites, like daisies or dandelions, the separate flowers have almost merged their distinct individualities in that of the complex whole. The calyx has become degraded into a mere bundle of hairs (known as a *pappus*), which serves as a float for the mature seed, and forms the "clock," blown away by village children from the withered dandelion head, as well as the gossamer-like wings that carry the thistle seeds among the farmer's corn. The involucre here usurps the whole protective function: and the head of flowers is mistaken by the ordinary human observer for a single blossom. But if we look close into the daisy, we see that its centre comprises a whole mass of little yellow bells, each of which consists of corolla, stamens, and pistil. The insect who alights on the head can take his fill in a leisurely way without moving from his standing-place; and meanwhile he is proving himself a good ally to the plant by fertilising one after another of its numerous ovaries. Each tiny bell by itself would prove too inconspicuous to attract much attention from the passing bee; but union is strength for the daisy as for the state, and the little composites have found their co-operative system answer so well, that late as was their appearance upon the earth, they are generally considered at the present day to be the most numerous family both in species and individuals of all flowering plants.

Nor has the process of differentiation stopped even here. Amongst the composites themselves great variety may be observed in the means adopted for the attraction of insects. The simplest form of composite head, which we see in the thistle and the artichoke, consists of uniform flowers, none differing in shape or colour from their neighbours. The common English centaury shows an intermediate stage, in which the outer florets are longer and larger than those in the centre of the head. The sunflower and the ragwort advance a step farther in the same direction, their outer florets having become ray-shaped or ligulate, but still preserving the yellow hue of the central mass. The ray florets, in these cases, practically fulfil the functions of petals, while the inner blossoms continue to act as true floral organs. Finally, in the daisy and in many chrysanthemums, the outer florets, besides being prolonged into petal-like rays, are coloured white, pink, mauve, or blue, while the central mass retains its original colouration. Here we find the external row of flowers quite diverted from its true purpose, and devoted almost exclusively to the attractive function.

Even now we have not yet arrived at the last stages of the differentiating process. The complex heads of flowers thus formed again unite into still more complex masses. The daisy and the sunflower bear only one composite head on each stalk, but the common thistle produces a whole mass of heads in a kind of umbel, and the ragwort has bunches of such umbels growing together side by side. In the groundsel, each head of flowers looks like a single blossom; in milfoil, the umbellate form is almost exactly reproduced in still wilder profusion; while the pretty waving golden-rod caps the climax by collecting compound bundles of heads into a many-branched and multitudinous plume. Flowers too small to succeed individually thus succeed in serried masses; and masses, again, too small for success in single complexity, achieve attention in their turn by reuniting into yet more complex groups.

As to the special colouring matter employed in each case, but little can be said as yet about its determining causes. In a few cases, indeed, we can conclude with some probability that the existing hue has been developed because it subserved, as such, some special function. Thus night-flowering plants are usually pure white or pale yellow, the very colours best adapted for scattering the scanty moonbeams or the dying twilight, and so attracting the eyes of moths and other crepuscular insects. Again, *Rafflesia, Hydnora, Stapelia,* and many other fetid flowers, which obtain fertilisation by deceiving flies through their resemblance to putrid meat, imitate the lurid appearance as well as the noisome smell of carrion. Many orchids are believed to be coloured in mimicry of insects, either for the sake of attraction or of protection from hurtful creatures. Other flowers appear to cater specially for the peculiar tastes of certain insects, which exhibit a preference for red, blue, yellow, or orange, as the case may be, and these will receive more extended treatment in the succeeding chapter. Sir John Lubbock thinks that the lines or spots on many flowers act as guides for the bees, pointing out the exact spot where the honey may be found; and Fritz Müller suggests that their changing hues serve as timepieces to show the right moment for effecting fertilisation.[1] But in the majority of cases we cannot point to any such special determining cause for the particular hue which we find in nature. It is known that the colouring matters of flowers may be divided into two classes, the *xanthic* and the *cyanic,* whose types are respectively yellow and blue; and these two classes do not readily pass into one another. Thus, we

[1] "Nature," November 29, 1877.

cannot have a blue rose or a blue dahlia, though we may vary the hues of either blossom by proper treatment almost indefinitely within the prescribed limit. Hence, it might appear that each flower produced as a rule those colours which most readily result from the chemical properties of its constituents, varying the tint, so far as possible, under the influence of insect selection, in accordance with the nature of the percipient eye, of the surrounding foliage, and of other adventitious circumstances in the environment. It might well happen, however, in the majority of cases, that *any* bright colour would equally answer the attractive purpose, supposing only it contrasted sufficiently with the green leaves or other objects in the natural background. Such, at least, we know to be the fact with the eye of man, who is struck indifferently by the golden orange, the ruddy strawberry, the rosy-cheeked mango, or the purple grape.

With regard to the infinite variety of tints which we find in various flowers, it is sufficient to remember that very slight alterations in the physical conditions or in the particular stock suffice artificially to produce such varieties among cultivated plants. Any one who looks at the multitudinous shades of garden hyacinths, dahlias, fuchsias, chrysanthemums, tulips, and pansies, need not wonder at the great profusion of colour in wild plants. Almost any shade seems easily procurable from another, provided only it does not overstep the natural limitation set down above. In all probability, the ordinary colouring matters of flowers differ from one another only in the minutest particulars of chemical composition.

So far we have been engaged in answering, to the best of our knowledge, the first question proposed above: Did flowers show an original tendency to the production of coloured adjuncts even prior to the selective action of insects? We have settled to our own satisfaction—I hope also to the satisfaction of the critical reader—that such an original and adventitious tendency *did* really exist; and we have traced it up through its various stages, as it became, from generation to generation, more and more purposive, until at last we have seen it culminate in the gorgeous peonies, tulips, lilies, and rhododendrons of our modern flower-gardens. But all this time we have been putting off the consideration of our second question: Did insects possess any tendency vaguely to discriminate the various colours apart from the reactive influence of entomophilous flowers? To this further inquiry we must now address ourselves for a few short minutes.

The answer must be a somewhat dubious one—in a certain sense negative, in another sense affirmative. There is no reason to think that insects could be definitely affected by various colours before the rise of bright-hued flowers had developed their colour-sense. But we must remember that while colours differ qualitatively for us, they also differ quantitatively in an absolute manner. Now, "to be affected more or less," as Professor Bain well puts it, "is a consequence of being affected at all;" and therefore every animal which has any organ for the perception of light must be capable of quantitatively differential stimulation by its greater or less intensity. Herein we have a slight original groundwork through which white might be distinguished by the primitive eye from green, brown, or black. But the growth of a distinctive mode of consciousness, or, to put it objectively, of distinct nerve-organs for the various waves of æther, must needs have been the result of long ages, during which those insects who best discriminated colour lived down on the average their less gifted compeers. How this result was brought about we cannot even guess, for here we find ourselves on the threshold of an ultimate metaphysical problem, unfathomable as yet—perhaps unfathomable for ever! *Why* the sensations of the auditory central organs should differ from those of the optical central organs; *why* the stimulation of a certain fibre and its connected ganglia should yield the feeling of blue, while the stimulation of its neighbour yields that of red—these final questions we cannot even pretend to guess. How the differentiation began, how it continued, how it acts to-day, we do not know, and very probably we may never know. But we *do* know this, that in a developed sensorium a differential sensation is attached to the differential stimulation of each among several very like nervous bodies; and that if it were not so, consciousness itself would be impossible.

Passing over this ultimate problem, however, it is not difficult to see how a substance so unstable and so modifiable as nerve-matter might easily present various modifications which answered to the various varieties of æther-wave falling upon it. If once such differentiated nerve-terminals began to exist, all experience and analogy show us that they would be followed by the differentiation of their connected nerve-centres, to each of which, in this mysterious way, a differentiated mode of consciousness would come to be attached. And this is what we mean by colour-sense.

Vague and symbolical as such a sketch confessedly must be, it would be foolish and premature to fill in any further conjectural details in the present state of our knowledge. We must accept it as a bare skeleton of the possible truth which fuller acquaintance with the nature of nerve-substance may some day flesh out for us in all its minor aspects. But we are not wholly without analogies which allow us faintly to foreshadow in our minds some indefinite hypothesis of its evolution. We know that a single material, such as glass, may be so moulded into globes that each globe will not only yield, when struck, a single constant note, but will also answer sympathetically to that note alone when sounded on another instrument. Now if we suppose that the nerve-terminals of the insect eye were similarly tuned at first, but so badly as to vibrate sympathetically with the whole gamut of separate æther-waves, we shall have a symbolical picture of an eye without a colour-sense. But if we further suppose that, under the influence of sundry incident causes unknown, certain among these nerve-terminals became restricted in the range of their sympathies, so as only to vibrate in unison with æther-waves having a limited range of frequency, then we shall have a symbolical picture of an eye with a rudimentary colour-sense. And if natural selection, picking out, as we know it would, from the whole number of variations in either direction those which varied most on the side of a still more limited range, at last produced terminals which were affected only by waves lying within an extremely small compass, we should then have the symbolical picture of an eye with a highly developed colour-sense. Rude as this representation of the possible course of evolution must obviously be, it may still answer the purpose of enabling the reader diagrammatically to grasp the idea which would otherwise float vaguely through his mind and elude every attempt to fix and crystallise it into thought. More than this humble service our rough and materialistic metaphor cannot pretend to perform.

And now, to recapitulate the chief points of this lengthy chapter, let us look back in imagination over the whole complex process here so imperfectly sketched out, and state our hypothetical conclusions, for clearness' sake, in the language of established fact. Amid the earliest forests of our earth, green cryptogamic vegetation formed the whole flora. But as time went on, the advantages of cross-fertilisation produced, through some unknown combination of circumstances, the earliest flowering plants. These, strengthened by the constant infusion of fresh blood (to use the familiar phrase), lived down the consanguineous offspring of the great ferns and horse-tails amongst which they grew. But such primeval flowering species were all fertilised by the aid of the wind, and possessed no bright corollas or other coloured adjuncts. The aspect of a palæozoic forest presented an almost unbroken sheet of monotonous verdure. Even then, however, a tendency towards the production of red or yellow juices and other colouring matters might have been noticed in certain portions of the different plants. The tendency was especially displayed in those parts of the organism where energies were being used up in the performance of physiological functions; this effect being due, perhaps, to the process of oxidation. Such phenomena might be noticed both in the dying leaves and in the youngest shoots; but they were also to be found in the floral organs and their neighbourhood. As yet, however, no eye could distinguish them as colours: they had only an objective existence as æther-waves of unusual simplicity and purity. But among these flowers a few undeveloped and unspecialised insects sought their food. Some of the blossoms thus obtained fertilisation more easily than before; and those among them which offered special attractions to the insects were able to effect a great economy of pollen, besides being impregnated with immensely greater certainty than their anemophilous competitors. Thus certain plants became permanently and regularly entomophilous. Thenceforward those entomophilous plants which produced the greatest quantities of insect food, as honey or pollen, were most often visited, and so most regularly fertilised. Again, out of this number, whatever individuals most conspicuously displayed the original tendency toward bright and distinctive colouration were most likely to strike the eyes of insects. Conversely, whatever insects most readily discriminated the nascent patches of colour were best able (other things equal) to secure their food. So the production of coloured floral whorls, and the perfectioning of the insect colour-sense, went on progressing side by side. The various flowers entered into unconscious competition with one another for the visits of their fertilisers; and those which could specially lay themselves out for the attention of a single species thereby procured impregnation with greater ease and certainty. Thus arose the quaintly-shaped bells, labiates, snapdragons, orchids, and other irregular flowers, whose forms are definitely correlated to those of their insect allies. Similarly, an insect with a specially long proboscis, and with certain hairy appendages on his legs or forehead, might at once abstract honey from flowers which no other insect could reach, and fertilise deeply-seated organs which no other insect would affect. Thus arose the specialised flower-feeders like bees and butterflies. Again, other flowers which separately failed to attract the proper insects might prove very alluring when massed in large bunches. The result is seen in the development of compound blooms like clover, lilac, horse-chestnut, and the various composites, which last undergo still further selections, ultimately producing yet more compound forms. At length the colour-sense of insects, thus aroused, strengthened, and fully developed, is employed for other purposes, of defence, protection, the chase after prey, the search for mates, or similar life-serving actions; and these activities once more react on the growing sense, so as to increase its definiteness and its worth. Last of all, the colour-sense is employed by the insects themselves, as we shall see in a future chapter, as an æsthetic instrument in the choice of mates, and so indirectly produces, through sexual selection, the brilliant hues of butterflies, beetles, and all the other exquisite winged or creeping articulates which fill the gorgeous cabinets of our museums.

In this list of what the colour-sense owes to the hues of blossoms, we might further include many facts with regard to humming-birds, sunbirds, and other flower-feeding vertebrates. But these belong properly to a later stage in our inquiry; and enough has already been said or hinted, I believe, to show how fundamental a fact in the history of the colour-sense and its reactions is the primitive tendency towards the display of bright hues around the floral reproductive organs. Already we have here, indeed, the origin of many among those brilliant objects which we noted as wanting in the Carboniferous world—the world without a colour-sense. We must hereafter go on to inquire what was the development of the remainder; and we shall find, when we search the records of evolution, that no small proportion of these, too, may be ultimately traced back, through some remote and indirect pedigree, to the lovely and varied tints of tropical or woodland flowers.

CHAPTER V.

THE COLOUR-SENSE IN INSECTS.

THROUGHOUT the whole of the preceding chapter we have taken for granted the existence of a developed colour-sense in some at least amongst the insects of modern times. We have tried to show what were the circumstances which gave it origin, and what the steps by which it reached its present supposed perfection. But now a deeper question arises, a question due to a destructive criticism which might seek to overthrow our whole superstructure by denying that modern insects do, as a matter of fact, possess any colour-sense whatsoever. In the face of such a possible criticism we must review all the various proofs of colour-perception in articulate animals which experiment or observation may reveal to our patient search.

This course is rendered the more necessary because within the last few years the existence of a faculty for the discrimination of different hues, even in primitive man himself, has been gravely called in question, both in this country and in Germany, by competent authorities in various walks of science or criticism. Mr. Gladstone first suggested that the Homeric poems contained no evidence of a colour-sense amongst the Akhaians of that early date.[1] Many years later, Dr. Lazar Geiger noticed that the colour-words employed in the Bible, the Vedas, the Zend-Avesta, and other early works, were very vague

[1] Gladstone, "Studies on Homer," vol. iii. § 4.

and indeterminate.[1] Dr. Magnus, a distinguished German oculist, next followed up the hint thus thrown out, and endeavoured to prove, in two learned pamphlets,[2] that the colour-perception of civilised man was a faculty of quite recent development, and that so lately as some 3000 years ago mankind was utterly incapable of distinguishing between violet, green, blue, and yellow. These views were further popularised by Mr. Gladstone in a later paper,[3] and have been partially adopted by several scientific authorities, including even that staunch evolutionist, Mr. A. R. Wallace, the joint-discoverer of natural selection.[4] Indeed, although the allegations of Dr. Magnus and his friends have not gone entirely unanswered,[5] yet it would seem as though the scientific world generally, in Germany at least, was prepared to accept them as representing the approximate truth.

To the evolutionist, however, this crude and ill-digested theory can hardly seriously recommend itself.[6] The supposition that any mode of perception so distinct and so varied as our colour-sense could be developed in the short space of time intervening between the Homeric Akhaians and our own epoch seems little short of incredible. The few centuries which have rolled past during that interval form but a single pulse of the pendulum whose seconds make up the epochs of geological evolution. To me, it appears rather that the colour-sense

[1] Zur Entwickelungsgeschichte der Menschheit, chap. iii., *passim*, Stuttgart, 1871.

[2] Die Geschichtliche Entwickelung des Farbensinnes, Leipzig, 1877, and in Preyer's Physiologischer Abhandlungen, I. ix. 515.

[3] "The Colour-Sense" in "Nineteenth Century," October 1877.

[4] "Colour in Animals and Plants," "Macmillan's Magazine," October 1877.

[5] Readers desirous of following up the whole discussion will find papers on this question by Mr. Darwin and Dr. Krause in "Kosmos," 1877, pp. 264, 423; by an anonymous critic in the Allgemeine Zeitung, March 8, 1878; by Prof. Blackie, read before the Royal Society of Edinburgh, January 1878; by Prof. Robertson Smith in "Nature," December 6, 1877; by Dr. Pole in "Nature," October 24 and 31, 1878; and by myself in "Mind," January 1878.

[6] I learn by a private letter from Mr. Wallace that, on fuller consideration, he cannot endorse Dr. Magnus's views so implicitly as he was at first inclined to do, and he has since partially retracted his adhesion in "Tropical Nature," p. 246.

of man is derived, through his mammalian ancestry, from a long line of anterior generations, and that its origin must be sought for in ages before a solitary quadrumanous animal had appeared upon the face of the earth. Holding this view, it becomes incumbent on me to propose a counter-theory to that of Dr. Magnus and Mr. Gladstone; a theory which will trace back our colour-sense to its ultimate sources in the bright hues of vegetal products like fruits and flowers. And it becomes necessary also to seek for every possible fact which goes to prove the existence of a similar faculty throughout the whole animal world. For if even man himself, "the head and crown of things," did not possess any such power until a few hundred years since, how can we suppose that the lower animals, including the humble little insects, have been for ages in enjoyment of this highest sensuous gift?

It may be asked, however, "Why take the trouble to search for recondite proofs on such a plain and straightforward subject? Why not try at once a few simple and direct experiments upon the colour-perception of various insects, beasts, and birds?" The suggestion is a natural one, and yet it is not so easy to act upon as would at first appear to be the case. Experiments of the sort are difficult to devise, and still more difficult to carry out successfully to any definite result. We cannot *ask* the animals to detail their sensations, and we find it hard to invent decisive or crucial tests of an objective character. A few lucky exceptions will be described in the following pages, but they are mere oases amongst a desert of lamentable failures. As a rule, animals refuse in the most provoking manner to take any notice of the psychological traps which you have carefully baited as tests of their sensations. For the most part, we must rely upon the less satisfactory method of observation, and upon various indirect conclusions, each of which has separately very little weight. In short, the evidence in favour of a colour-sense amongst the lower animals is purely *cumulative*. Each link in the argument is but a slender support; yet I hope to show as we proceed that the whole strand, formed of variously twisted chains, is collectively strong enough and sure enough to support the burden of a weighty conclusion.

Happily, as regards the higher insects, we can start fair with a set of decisive experiments tried by Sir John Lubbock. That patient and minute observer saw grounds for believing that bees were attracted by the hues of flowers. However, to make assurance doubly sure, he placed slips of glass smeared with honey on paper of various colours, black, white, yellow, orange, blue, and red. The general results may be given in the original words. "A bee which was placed on the orange returned twenty times to that slip of glass, only once or twice visiting the others, though I moved the position and also the honey. The next morning again two or three bees paid twenty-one visits to the orange and yellow, and only four to all the other slips of glass. I then moved the glass, after which, out of thirty-two visits, twenty-two were to the orange and yellow."[1] However, this preference did not depend upon an inability to discern the blue, for on another occasion, says the author, "I had ranged my colours in a line, with the blue at one end. It was a cold morning, and only one bee came. She had been several times the preceding day, generally to the honey which was on the blue paper. This day also she came to the blue. I moved the blue gradually along the line one stage every half hour, during which time she paid fifteen visits to the honey, in every case going to that which was on the blue paper." Sir John Lubbock, however, never relies upon single or few experiments. Accordingly, he tried once more at a later date with greater variation in the circumstances. "On the 12th of July," he says, "I brought a bee to some honey which I placed on blue paper, and about three feet off I placed a

[1] Journal of the Linnean Society, vol. xii. p. 129. I have to thank Sir John Lubbock for kindly forwarding me copies of all his papers and lectures on this interesting question.

similar quantity of honey on orange paper. After she had returned twice, I transposed the papers; but she returned to the honey on the blue paper. After she had made three more visits, always to the blue paper, I transposed them again, and she again followed the colour, though the honey was left in the same place." A series of careful observations followed, which are detailed in a tabular form; but my readers will probably be satisfied with a general summary, to the effect that thirty consecutive visits were all made to the same colour, in spite of four separate transpositions. On one of these occasions, says Sir John, "At 8.5 she returned to the old place, and was just going to alight; but observing the change of colour, without a moment's hesitation darted off to the blue. No one who saw her at that moment could have entertained any further doubt about her perceiving the difference between the two colours."[1]

Similar results were obtained with wasps. At 6 A.M. on September 13, 1875, Sir John observes, "I put a wasp to some honey on green paper and about a foot off I put some more honey on orange paper. The wasp kept returning to the honey at the usual intervals. At 8.30 I transposed the papers; but the wasp followed the colour. At 9 o'clock I transposed the papers again, but not the honey; she returned again to the green, from which it would appear that she was following the colour, not the honey. At 10.20 I again transposed them, with the same result."[2]

It should be mentioned, however, that later experiments led Sir John Lubbock to the conclusion that bees do not so easily discriminate between blue and green as between other colours—a very natural fact, considering how slight is the objective difference between these shades. It would also appear that though wasps can distinguish colours, they are less guided by them than is the case with bees.[3] This we might have expected *a priori* from

[1] Journal of the Linnean Society, vol. xii. p. 232.

[2] Ibid., p. 237.

[3] See part iv. of Sir John Lubbock's investigations in Journ. Linn. Soc., vol. xii. p. 512 *seq.*

the diversity of habits of the two insects, and we shall see hereafter that the difference has important bearings on the question of relative tastes.

With respect to ants, Sir John Lubbock's experiments, though read before the Linnean Society, have not at the date of writing yet been published in its Transactions. It must suffice, therefore, without anticipating the author's statement, to notice here, that though these insects are very defective in the sense of vision, depending much more largely upon touch and smell, they are evidently affected in a distinctive manner by the red and violet ends of the spectrum. Of course the habits of ants would not lead us to credit them with the necessary circumstances for giving rise to a developed colour-sense; nor are their reactions on external nature of the same startling character as those which we observe in the case of the fully-winged insects, like bees and butterflies. Nevertheless, it is interesting to observe that even here a groundwork of faint discrimination evidently exists, which might possibly have been developed into a perfect sense had the circumstances of ant-life so determined its evolution.

Observation in many ways confirms the results thus obtained by experiment. Let us look first at the evidence on this head which can be derived from the visits of bees and butterflies to flowers.

We have seen already that one main difference between anemophilous and entomophilous flowers consists in the fact that while the former are usually small, greenish, and inconspicuous, the latter are usually large, brilliant, and deeply coloured with white, red, blue, or yellow. We have the high authority of Mr. Darwin for the statement, as an invariable rule, "That when a flower is fertilised by the wind it never has a gaily-coloured corolla."[1] And though the converse proposition is not strictly true in every case, yet a large proportion of those blossoms which

[1] Origin of Species, p. 127.

depend for fertilisation upon insects are noticeable for their bright and flaunting hues.

Now, the structures in which the brilliant pigments reside have absolutely no function except that of attracting the insect agents for fertilisation. But these structures, as we have already seen, are produced by the plant at an enormous physiological cost, often so as to engage by far the greater portion of all its energies. Unless we allow, then, that roses, tulips, lilies, and rhododendrons have developed their large and showy corollas for the sake of alluring their insect allies, we shall be reduced to believe that they have produced these expensive and useless adjuncts for no other purpose than that of wasting their substance in riotous living. Such a supposition involves a simple physical absurdity. If any plant could, by any accidental combination of circumstances, once acquire so bad a habit, it must necessarily stand at a disadvantage in comparison with all other plants, and so be quickly extinguished in the ceaseless struggle and competition of terrestrial life. We cannot for a moment believe that any structure could exist at all, far less spread itself through all the most successful species of a dominant class, unless it subserved some function of great utility to the organism in which it is found.

Nor are we left here entirely to such *a priori* reasoning. It happens that a few aberrant plants possess two forms of flowers—the one entomophilous, and often appearing in the spring; the other self-fertilised, and often appearing in the autumn. Of this phenomenon the common violet offers a well-known example. The entomophilous blossoms, which seem to be frequently sterile, and to answer the purpose of such occasional cross-fertilisation as may keep up the vigour of the stock, are distinguished by the usual coloured corolla, as well as by a sweet and attractive perfume in certain species. But the self-fertilised or *cleistogamous* blossoms, which in many ways recall the spore-cases of cryptogams, are quite green and inconspicuous, so much so, that no ordinary observer would call them flowers at all, but would set them down as fruits or seed-vessels. These latter blossoms do most of the effective reproductive work; but as they do not aim at cross-fertilisation, and so do not require the aid of insects, they have entirely lost all semblance of coloured floral whorls, and consist merely of hidden fructifying elements. Thus nature herself, as it were, makes an experiment for us which clearly demonstrates, by the Method of Difference, the real function of the pigmented corolla.

Like results are shown in the case of many plants belonging to mainly entomophilous families. True anemophilous flowers, whose ancestors have been anemophilous for all past generations, and have never learnt to depend upon insects at all, possess only the two effective sexual whorls, with at most some appendage having more or less the nature of a calyx. But certain plants, which apparently belong by descent to mainly entomophilous tribes, seem to have dropped the habit of insect-fertilisation, and to have reverted once more to wind-fertilisation. In all (or almost all) these cases, where the corolla still exists at all in a rudimentary form, bearing witness to their ancestral habit, the petals have grown quite small and dwarfed (because their original function is gone), and have once more resumed the green appearance of ordinary leaves. In short, we see that where flowers require the aid of insects they almost always bid for it by assuming bright hues; but that those flowers, anemophilous or cleistogamous, which do not need their aid, are normally destitute of such hues, while those plants which once required their aid, but have ceased to do so, rapidly lose their coloured adjuncts, in accordance with that Law of Parsimony whereby all structures whose functions are no longer necessary become finally obsolescent. How these facts can be accounted for if we suppose insects to be destitute of a colour-sense it would baffle the cleverest theorist to say.

In some few instances we even possess actual proof that insects are attracted by the bright hues of petals. Thus Mr. Anderson noticed that when the corolla of certain blossoms, so constructed as to favour or almost ensure cross-fertilisation, had been cut away, the insects never discovered or visited the flowers.[1] "I proved the importance of the gaily coloured corolla," says Mr. Darwin, "by cutting off the large lower petals of several flowers of *Lobelia erinus*, and these flowers were neglected by the hive-bees, which were incessantly visiting the other flowers."[2]

Descending to particular instances, we find that while most bright-coloured blossoms offer the visiting insect some real advantage in the shape of honey, other unprincipled plants, trading upon the general faith in a connection between colour and food, delude insects into visiting them by their hue alone.[3] Again, certain insects, as Müller has observed, visit certain flowers only; and in other cases, a particular insect, during a single day, confines himself, for some reason of his own, to some one chosen species. Numerous naturalists have put on record the preferences which individual insects have shown on special occasions for one kind of blossom alone. A single case must suffice for all. That careful observer, Mr. H. O. Forbes, saw "by the roadside, near Kew Bridge Station, several species of Hymenoptera, of the genus *Bombus* principally; one visited thirty flowers of *Lamium purpureum* in succession, passing over without notice all the other plants on the same bank—species of *Convolvulus*, *Rubus*, *Solanum*. Two other species of *Bombus* and a *Pieris rapæ* also patronised the *Lamium*, seeking it out deep in the thicket, thrusting their probosces even into withered cups, although the *Rubus* flowers were far more accessible, and seemed much more attractive, being fresh and well-expanded."[4] The pages of scientific journals

[1] Darwin, "Cross and Self-Fertilisation of Plants," p. 87.

[2] Ibid., p. 176.

[3] Lubbock, "British Wildflowers," p. 11.

[4] "Nature," November 22, 1877.

during the last few years have positively teemed with similar instances from all parts of the world.

Furthermore, the varying colours of flowers seem adapted, as we saw in the last chapter, to attract particular insects at particular periods of inflorescence. I have already mentioned the case of a *Lantana* described by F. Müller as altering in hue at different times during its maturation, being yellow on the first, orange on the second, and purple on the third day. "This plant," says Müller, "is visited by various butterflies. As far as I have seen, the purple flowers are never touched. Some species inserted their proboscis both into yellow and into orange flowers (*Danais erippus, Pieris aripa*); others, as far as I have hitherto observed, exclusively into the yellow flowers of the first day (*Heliconius apseudes, Colœnis julia, Eurema leuce*). . . . If the flowers fell off at the end of the first day, the inflorescence would be much less conspicuous: if they did not change their colour, much time would be lost by the butterflies inserting their proboscis in already fertilised flowers."[1] In another species of the same genus the flowers are lilac, but the entrance of the tube is marked with yellow, surrounded by a white circle. These yellow and white markings, which probably serve as guides for the insect allies, disappear entirely on the second day.

And now, from the evidence supplied by flowers, we may pass on to the evidence supplied by the colours of insects themselves. I do not here propose to enter upon the consideration of those hues which depend for their origin upon sexual selection; that part of our cumulative argument must be delayed to a later chapter. But we may fittingly consider at the present point the proofs of a colour-sense in insects afforded by the curious phenomenon of mimicry, so fully illustrated by Mr. Wallace and Mr. Bates.

It is now an established fact that certain animals have

[1] "Nature," November 29, 1877.

survived in the struggle for existence by means of some special resemblance to other species or to objects in the environment which gives them a special chance of deceiving prey, escaping the notice of enemies, or adopting some similar protective device. Colour enters largely into the special adaptations thus produced, and many insects have been largely modified in their colouration by the action of such mimetic selection. But, as a rule, the particular hues or lines have reference less to the eyes of insects themselves than to the eyes of the reptiles, birds, or mammals which prey upon them; and these cases will therefore be more fully considered when we come to treat of the colour-sense in vertebrates. In a few instances, however, protective imitation seems to have been produced in certain insects with reference to the eyes of other species in their own class; and these latter cases may properly be treated under the present heading.

First of all, we may take the instance of those flies which live in a sort of social parasitism among the hives or nests of bees. These flies have acquired belts of colour and other imitative appendages closely resembling those of the host upon whose stores they commit their depredations, while their larvæ actually live by devouring the larvæ of the bees themselves. Obviously, any fly which entered a beehive could only escape detection and extermination at the hands of its inhabitants, provided it so far resembled them as to be mistaken at a first glance by the community for one of their fellows. Thus any fly which showed the slightest superficial resemblance to a bee might at first be enabled to rob their storehouses with impunity, while such flies would escape continued detection from generation to generation just in proportion as they more and more closely approximated to the appearance of their unwilling hosts. For, as Mr. Belt has well pointed out, while the mimicking species would become naturally more numerous from age to age, the senses of the mimicked species would become naturally sharpened by the habit of detecting flimsy pretences; and so at last very close resemblance might be expected to arise.[1] In the particular instance now under notice, I learn from Mr. Lowne, who has carefully measured the curvature of the facets in the compound eyes of insects (upon which, of course, depends the minimal size of apprehensible objects), that the mimicry has proceeded just so far as the structure of the bee's eye would lead him to expect, and no further. In other words, Mr. Lowne is inclined to suppose, if measurements of angular distance subtended can guide him, that such a fly is indistinguishable by a bee from one of his own species within the limits of ordinary vision.[2]

Mr. Bates mentions a still more interesting case of some showy coloured Brazilian spiders (which, of course, are not themselves insects in the scientific sense), "who double themselves up at the base of leaf-stalks, so as to resemble flower-buds, and thus deceive the insects upon which they prey."[3] Sir Joseph Hooker believes that an Indian *Mantis*, or praying-insect, similarly deludes the little creatures which form its food by its extraordinary likeness to a leaf.[4] Another rapacious example of the same genus exactly mimics the white ants, whom it devours quietly and unsuspected.[5] But all these curious facts are thrown into the shade by a third *Mantis*, for which Sir Charles Dilke stands as voucher—a bloodthirsty wretch, whose head and fangs have been moulded into the image of an orchid, with a deceptive blossom which closes upon the insect who seeks for food in its treacherous arms.

Sometimes even higher animals seem to have acquired

[1] The Naturalist in Nicaragua, p. 383.

[2] For a very perfect instance of such mimetic resemblance, where the colour is especially noticed in great detail, see an interesting paper by Mr. Neville Goodman in "Proc. Camb. Phil. Soc.," vol. iii. part 2, March 1878, p. 25. In this case the mimicker was a Syrian *Laphria*, and the creature mimicked a wasp.

[3] The Naturalist on the Amazons, p. 54.

[4] Himalayan Journal, vol. ii. p. 306.

[5] Wallace, "Contributions to the Theory of Natural Selection," p. 98.

similar disguises in order to deceive the insects for which they lie in wait. Thus Mr. Belt notices a green Nicaraguan lizard, looking like the herbage by which it is surrounded, and decked with leaf-like expansions, which serve to conceal its predacious nature from passing beetles or flies.[1] How far the greenness of lizards and forestine birds in general, or the sandy hue of those which frequent deserts, may serve them as aids in escaping the notice of prey upon which they creep, is too uncertain a question to be urged in evidence as to the colour-sense of insects, and yet too interesting to be passed by without at least an allusion.

In all these instances, various predatory species have acquired mimetic resemblances for the sake of deceiving their quarry; but in other cases the defenceless booty turns the tables upon the tyrants, and is accordingly enabled to elude their hungry quest. Thus Mr. Wallace tells us of a cricket which exactly reproduces the features of its foe the sandwasp;[2] while Mr. Belt saw a green leaf-like locust, overrun by foraging ants, yet remaining as motionless as the leaves, whose colour and texture it so faithfully mimicked. This latter creature appeared to have some dim instinctive knowledge of the fact that its safety depended upon its absolute immobility, for even when lifted by the hand from the ground, it continued strenuously to preserve its rigid attitude.[3]

But indeed, to any mind unbiassed by preconceptions derived from another sphere of thought, the grand evidence in favour of an insect colour-sense is to be found, not in isolated instances, but in the broad expanse of meadow and hillside around us. The million hues of spring or summer flowers have no meaning and no explanation on any other hypothesis. The colour-sense of bees and butterflies has metamorphosed the world; and

[1] Naturalist in Nicaragua, p. 12.
[2] Contributions to the Theory of Natural Selection, p. 99.
[3] Naturalist in Nicaragua, p. 19.

the colours of organic beings were originally developed by natural causes, with a sort of divine afterthought regarding the pleasure which man might derive from their contemplation, yet we cannot blind ourselves to the absolute necessity of their performing from the very first some special utilitarian function. Not even the watchmaker deity of Paley himself, one may suppose, would have invented flowers in the Secondary age for the sole gratification of man in the Post-tertiary. To put it briefly, if insects have not a colour-sense, then the whole universe must be nothing more than a singularly happy concourse of fortuitous atoms. The theist and the evolutionist are equally ready to disclaim with all their might this grotesque and monstrous supposition.

CHAPTER VI.

BIRDS OR MAMMALS AND FRUITS.

WHAT insects are to bright-hued flowers, birds and mammals are to bright-hued fruits. And we might almost say, though with more reservation, what flowers are to the colour-sense in insects, fruits are to the colour-sense in birds and mammals.

Accordingly, we may fairly conclude that bright-coloured fruits belong to a much later geological age than entomophilous blossoms.[1] We need not here transport ourselves in imagination to the green expanse of palæozoic jungles, unenlivened by scarlet flowers or gaudy insects; we have only to place ourselves amid the comparatively modern flora of the Tertiary age, surrounded by forest trees of familiar aspect, and tenanted by animals whose shape differs but little from those of our own historical epoch. Already the ground spreads a carpet of soft grass beneath our feet; already simple forms of insect-fertilised blossoms stand out in profusion as brilliant points of colour among the green foliage around. It is true we see no highly-differentiated daisies or thistles, with their clustered heads of tubular bells; no strangely-shaped orchids or snapdragons, with their forms nicely adjusted to those of the fertilising bees; but we find a fair abundance of unspecialised flowers, with a regular corolla of separate pieces, such as we know so well in the buttercup, the poppy, or the geranium. Moreover, we may see among them, not merely the little dingy creeping insects of the

[1] See Wallace's "Tropical Nature," p. 228.

Carboniferous deltas, but flitting butterflies with coloured wings, and flower-haunting beetles of exquisite metallic sheen. These brighter forms of insect life have been developed in the vast cycles of that immeasurable interim by the selective action of sexual preference, working through a taste for brilliant hues which has been originally formed in the search for food; but this portion of our subject we must remove from its proper historical place, owing to the exigencies of logical treatment, and relegate it to a later chapter, where we may consider the question of sexual selection in its ensemble, as exhibited throughout all departments of the animal kingdom. For the present, we must content ourselves by taking for granted the existence among the Tertiary forests of gaily-tinted insects and gorgeous lizards, as well as that of crimson leaves and orange blossoms. Nay, more, we may probably allow that the higher vertebrate types which lived in those primitive modern wilds possessed some more or less distinct form of colour-perception, derived perhaps from their earlier marine ancestors, and kept alive by exercise upon these varied objects in their actual environment. Yet, in spite of such facts and probabilities, it will be well worth while briefly to trace the origin of bright-hued fruits, as we have already traced the origin of bright-hued flowers, both because the colour-sense of the highest vertebrates probably owes much to the reaction of these brilliant food-stuffs, and because the taste for colour in man himself may be plausibly referred to the arboreal habits of his ante-human progenitors. Furthermore, we shall see reason to conclude hereafter that the plumage of the most beautiful birds and the fur or skin of the most highly-coloured mammals are due to the love for bright hues originally developed in connection with the pulpy fruits; and this conclusion affords another reason why we should first inquire into the history of their evolution.

The ultimate object of flowering is the production of seeds, that is to say, of embryo plants, destined to replace their parents, and continue the life of the species to future generations. The vessel which includes one or more such seeds, the produce of a single flower, is known in botanical parlance as a fruit. But as it often happens that the ripe pistils of more than one blossom become united together into a single mass, instances of which habit may be seen in the fig and the mulberry, it becomes convenient to describe these aggregate seed-vessels also as compound fruits. In the language of ordinary life, however, a fruit means something very different from such hard and dry seed-vessels as those of poppies, beans, or thistles. We understand by the word, in daily usage, some sweet, soft, pulpy object, more or less connected with the seeds, and usually possessing some bright-coloured portion. To these latter structures we shall generally give the designation of fruits-proper, to distinguish them from such among their like as are merely fruits by botanical courtesy. Fruits-proper, then, in this restricted sense, form the special object of our present investigation.

The botanical fruit consists of a covering or pericarp, often extremely thin and almost papery, enclosing one or more ripe seeds. But other connected portions of the plant, for example, the swollen flower-stalk and the receptacle, frequently coalesce so thoroughly with these essential organs that it becomes impossible to distinguish them, even for technical purposes. This is especially the case with fruits-proper, where the edible portion quite as often consists of some irregular adjunct as of the juicy pericarp itself. Accordingly, in the following account, I shall take the liberty of dealing a little broadly with the technical terms of botany, suppressing all unnecessary detail, and only dwelling upon the simplest and most salient points.

The ideal form of fruit would consist of a plain pericarp enclosing a single seed; and though such fruits are comparatively rare, one may reasonably suppose that the earliest flowering plants would in all probability produce seed-vessels of a very simple kind, in which the separate seeds were small and inconspicuous, though relatively numerous. Indeed, the gymnosperms, or pine and cycad group, which appeared upon the earth before any other phanerogamous plants, cannot be said to possess any fruit at all in the proper sense of the term. Moreover, there is reason to believe that early plants produced large quantities of seeds which were relatively ill provided with coverings or nutriment, and which depended rather upon their number than upon any special adaptation for their chance of survival. But as time went on, slight adventitious variations in the nature of the seeds or their coverings might prove useful in protecting them from some one or other among the numerous dangers to which their fellows were exposed, and so might give them an extra advantage in the struggle for existence. The most noticeable among these variations is, that which consists in the extra supply of energetic material for the sprouting plantlet.

A young plant consists of an embryo whose growth depends upon the liberation of energy contained in its hydro-carbonaceous or albuminoid materials, by union with the free oxygen of the air. The energetic substances upon which it feeds were laid up for it by the parent plant, either in the growing seed-leaves (cotyledons), as in the case of the pea and bean, or in a separate albuminous mass, as in the case of the wheat tribe. But such energetic materials are exactly the portions of plants which form the best food-stuffs for animals; and accordingly, as birds and mammals multiplied upon the face of the earth, it must happen that those very seeds which possessed the best chance of survival through their stores of nutriment would also be the ones which lay most exposed to the ravages of animal foes. Hence plants are compelled to adopt many devices whereby they may secure themselves against such depredations.

One common plan is that by which some underground structure, such as a bulb, tuber, corm, or root, is made to supplement, or in many cases almost to supersede, the natural mode of reproduction by seeds. This is seen in numerous plants, such as potatoes, onions, beets, and many grasses. But perhaps the most interesting case is that of the ground-nuts, whose "hypogean" fruit is buried deep in the earth, so as to escape the notice of all but burrowing animals. Yet even these species, which try to conceal their stores of food by hiding them under the soil, fall a prey at last to the snouts of rodents or swine. In fact, it must naturally happen that, as young plants and animals feed on exactly the same energetic substances, every device on the part of the plant will soon be met by a counter-device on the part of the hungry animal.[1]

Each species of plant must, of course, solve for itself the problem, during the course of its development, whether its energies will be best employed by hoarding nutriment for its own future use in bulbs and tubers, or by producing richly-endowed seeds which will give its offspring a better chance of rooting themselves comfortably, and so surviving in safety amid the ceaseless competition of rival species. The various cereals, such as wheat, barley, rye, and oats, have found it most convenient to grow afresh with each season, and to supply their embryos with an abundant store of food for their sustenance during the infant stage of plant life. Their example has been followed by peas and other pulses, by the wide class of nuts, and by the majority of garden fruits. On the other hand, the onion and the tiger-lily store nutriment for themselves in the underground stem, surrounded by a mass of overlapping or closely-wound leaves, which we call a bulb; the iris and the crocus lay by their stock of food in a woody or fleshy stalk; the potato makes a rich deposit of starch in its subterraneous branches or tubers; the turnip, carrot, radish, and beet use their root as the storehouse for their hoarded food-stuffs; while the orchis

[1] See an article on "The Origin of Fruits" in the Cornhill Magazine for August 1878, a large part of which I have transferred to this chapter.

produces each year a new tubercle by the side of its existing root, and this second tubercle becomes in turn the parent of its next year's flowering stem. Perhaps, however, the common colchicum or meadow-saffron affords the most instructive instance of all; for during the summer it sends up green leaves alone, which devote their entire time to the accumulation of food-stuffs in a corm at their side; and when the autumn comes round, this corm produces, not leaves, but a naked flower-stalk, which pushes its way through the moist earth, and stands solitary before the October winds, depending wholly upon the stock of nutriment laid up for it in the corm.

Now, if we look at the materials used as food by man or other frugivorous creatures, we shall see that they consist almost universally of these reservoirs of energetic material, laid up by the plant for itself or its descendants. It is true that the graminivorous animals, like deer, sheep, cows, and horses, live mainly off the green leaves of grasses and creeping plants. But we know how small an amount of food they manage to extract from these fibrous masses, and how constantly their whole existence is devoted to the monotonous and imperative task of grazing for very life. Those animals, however, who have learnt to live at the least cost to themselves always choose the portions of a plant which it has stored with nourishment for itself or its offspring. Men and monkeys feed naturally off fruits, seeds, and bulbs. Wheat, maize, rye, barley, oats, rice, millet, pease, vetches, and other grains or pulses, form the staple sustenance of half mankind. Other fruits largely employed for food are plantains, bananas, bread-fruit, dates, cocoa-nuts, chestnuts, mangoes, mangostines, and papaws. Among roots, tubers, and bulbs stored with edible materials may be mentioned beet, carrot, radishes, turnips, swedes, ginger, potatoes, yam, cassava, onions, and Jerusalem artichokes. But if we look at the other vegetables used as food, we shall observe at once that they are few in number and unimportant in economical value. In cabbage, Brussels sprouts, lettuce, succory, spinach, and watercress, we eat the green leaves; yet nobody would ever dream of making a meal off any of these poor food-stuffs. The stalk or young sprout forms the culinary portion of asparagus, celery, seakale, rhubarb, and angelica, none of which vegetables are remarkable for their nutritious properties. In all the remaining food-plants some part of the flowering apparatus supplies the table, as in true artichokes, where we eat the receptacle, richly stocked with nutriment for the opening florets; or in cauliflower, where we choose the aborted flower-buds themselves. In short, we find that men and the higher animals generally support themselves upon those parts of plants in which energy has been accumulated either for the future growth and unfolding of the plant itself, or for the sustenance of its tender offspring.

Doubtless the earliest seeds differed but little from the spores of cryptogams in the amount of nourishment with which they were provided, and the mode in which they were dropped upon the nursing soil beneath. But during the great secondary and tertiary ages of geology, throughout whose long course first the conifers and then the true flowering plants slowly superseded the gigantic horse-tails and tree-ferns of the coal-measures, many new devices for the dispersion and nutrition of seeds were gradually developed by the pressure of natural selection.[1] Those plants which merely cast their naked embryos adrift upon the world to shift for themselves in the fierce struggle of stout and hardy competitors must necessarily waste their energies in the production of an immense number of seeds. In fact, calculations have been made which show that a single scarlet corn-poppy produces in one year no less than 50,000 embryos; and some other species actually exceed

[1] I trust that in the sequel the critical botanist will excuse me for having neglected the strict terminology of carpological science, and made no distinction between seeds and fruits. Some little simplification is absolutely necessary for general readers in this the most involved department of structural botany.

this enormous figure. If, then, any plant happens, by a favourable combination of circumstances, to modify the shape of its seed in such a manner that it can be more readily conveyed to open or unoccupied spots, it will be able in future to economise its strength, and thus to give both itself and its offspring a better chance in the struggle for life. There are many ways in which natural selection has effected this desirable consummation.

The thistle, the dandelion, and the cotton-bush provide their seeds with long tufts of light hair, thin and airy as gossamer, by which they are carried on the wings of the wind to bare spaces, away from the shadow of their mother-plant, where they may root themselves successfully in the vacant soil. The maple, the ash, and the pine supply their embryos with flattened wings, which serve them in like manner not less effectually. Both these we may classify as *wind-dispersed* seeds. A second set of plants have seed-vessels which burst open explosively when ripe, and scatter their contents to a considerable distance. The balsam forms the commonest example in our European gardens; but a well-known tropical tree, the sandbox, displays the same peculiarity in a form which is almost alarming, as its large, hard, dry capsules fly apart with the report of a small pistol, and drive out the disc-shaped nuts within so forcibly as to make a blow on the cheek decidedly unpleasant. These we may designate as *self-dispersed* seeds. Yet a third class may be conveniently described as *animal-dispersed*, divisible once more into two sub-classes, the involuntarily and the voluntarily aided. Of the former kind we have examples in those seeds which, like burrs and cleavers, are covered with little hooks, by whose assistance they attach themselves to the fur or wool of passers-by. The latter or voluntarily aided sort are exemplified in fruits-proper, the subject of our present investigation, such as apples, plums, peaches, cherries, haws, and brambleberries. Every one of these plants is provided with hard and indigestible seeds, coated or surrounded by a soft, sweet, pulpy, perfumed, bright-coloured, and nutritious covering known as fruit. By all these means the plant allures birds or mammals to swallow and disperse its undigested seed, giving in, as it were, the pulpy covering as a reward for the services thus conferred.

But before we go on to inquire into the mode of their development we must glance briefly at a second important difference in the constitution of seeds.

If we plant a grain of mustard-seed in moist earth, and allow it to germinate, we shall see that its young leaves begin from the very first to grow green and assimilate energetic matter from the air around them. They are, indeed, compelled to do so, because they have no large store of nutriment laid up in the seed-leaves for their future use by the mother-plant. But if we treat a pea in the same manner, we shall find that it long continues to derive nourishment from the abundant stock of food treasured up in its big round seed-leaves. Now of course any plant which thus learns to lay by in time for the wants of its offspring gives its embryo a far better chance of surviving and leaving descendants in its turn than one which abandons its infant plants to their own unaided resources in a stern battle with the unkindly world. Exactly the same difference exists between the two cases as that which exists between the wealthy merchant's son, launched on life with abundant capital accumulated by his father, and the street Arab, turned adrift as soon as he can walk alone, to shift or starve for himself in the lanes and alleys of a great city.

So then as plants went on varying and improving under the stress of over-population, it would naturally result that many species must hit independently upon this device of laying by granaries of nutriment for the use of their descendants. But side by side with the advancing development of vegetable life, animal life was also developing in complexity and perfect adaptation to its circumstances. And herein lay a difficult dilemma for the plant. On the one hand, in order to compete with its neighbours, it must lay up stores of starch and oil and albumen for the good of its embryos; while, on the other hand, the more industriously it accumulated these expensive substances, the more temptingly did it lay itself open to the depredations of the squirrels, mice, bats, monkeys, and other clever thieves, whose number was daily increasing in the forests round about. The plant becomes, in short, like a merchant in a land exposed to the inroads of powerful robbers. If he does not keep up his shop with its tempting display of wares, he must die for want of custom; if he shows them too readily and unguardedly, he will lay himself open to be plundered of his whole stock-in-trade. In such a case the plant and the merchant have recourse to the self-same devices. Sometimes they surround themselves with means of defence against the depredators; sometimes they buy themselves off by sacrificing a portion of their wealth to secure the safety of the remainder. Those seeds which adopt the former plan we call *nuts,* while to those which depend upon the latter means of security we give the name of *fruits.*

A nut is a hard-coated seed, which deliberately lays itself out to escape the notice and baffle the efforts of monkeys and other frugivorous animals. Instead of bidding for attention by its bright hues, like the flower and fruit, the nut is purposely clad in a quiet coat of uniform green, indistinguishable from the surrounding leaves during its earlier existence, while afterwards it assumes a dull brown colour as it lies upon the dusky soil beneath. Nuts are rich in oils and other useful food-stuffs; but to eat these is destructive to the life of the embryo, and therefore the nut commonly surrounds itself with a hard and stony shell, which defies the stoutest teeth to pierce its thickened walls. Outside this solid coating it often spreads a softer covering with a nauseous, bitter taste, so familiar to us all in the walnut, which at once warns off the enemy from attacking the unsavoury morsel. Not content with all these protective devices of colour, taste, and hardness, the nut in many cases contains poisonous juices, and is thickly clad in hooked and pointed mail, which wounds the hands or lips of the would-be robber.[1] In brief, a nut is a seed which has survived in the struggle for life by means of multiplied protections against the attacks of enemies. We cannot have a better instance of these precautions than the common cocoa-nut palm. Its seed hangs at a great height from the ground on a tall and slender stem, unprovided with branches which might aid the climber, and almost inaccessible to any animal except the persevering monkey. Its shell is very thick and hard, so extremely impermeable that a small passage has to be left by which the germinating shoot may push its way out of the stronghold where it is born. Outside this shell, again, lies a thick matting of hairy fibres, whose elasticity breaks its fall from the giddy height at which it hangs. Yet, in spite of all these cunning precautions, even the cocoa-nut is not quite safe from the depredations of monkeys, or, stranger still, of tree-climbing crabs. The common Brazil-nuts of our fruiterers' shops are almost equally interesting, their queer, shapeless forms being closely packed together, as they hang from their native boughs, in a hard outer shell, not unlike that of the cocoa-nut. It must be very annoying to the unsuspecting monkey, who has succeeded after violent efforts in breaking the external coat, to find that he must still deal with a mass of hard, angular, and uncanny nuts, which sadly cut his tender gums and threaten the stability of his precious teeth—those invaluable tools, which serve him well in the place of knives, hammers, scissors, and all other human implements.

A fruit-proper, on the other hand, lays itself open in every way to attract the attention of animals, and so to be dispersed by their aid, often amid the nourishing refuse

[1] See Wallace's "Tropical Nature," p. 225 *seq.* I may perhaps be allowed to add that the article in the "Cornhill Magazine" from which this passage is extracted was in proof before the appearance of Mr. Wallace's book, though not published till some months later.

of their meals. It is true that, with the fruit, as with the nut, to digest the actual seed itself would be fatal to the life of the young plant. But fruits get over this difficulty by coating their seeds first with a hard, indigestible shell, and then with a soft, sweet, pulpy, and nutritious outer layer. The purely accidental or functional origin of this covering is testified by the immense variety of ways in which it has been developed. Sometimes a single seed has shown a slight tendency to succulence in its outer coat, and forthwith it has gone on laying up juices from generation to generation, until it has developed into a one-seeded berry. Sometimes a whole head of seeds has been surrounded by a fleshy stem, and the attention of animals has thenceforward encouraged its new habit by ensuring the dispersion of its embryos. A few of the various methods by which fruits attain their object we shall examine in detail further on: it will suffice for the present to point out that any property which secured for the seed dispersion by animal agency would at once give it an advantage over its fellows, and thus tend to be increased in all future generations.

So, then, as birds, squirrels, bats, monkeys, and the higher animals generally increased on the face of the earth, every seed which showed a tendency to surround itself with succulent pulp would obviously gain a point thereby in its rivalry with other species. Accordingly, as we might naturally expect, fruits which have been developed to suit the taste of birds and mammals are of much more recent geological origin than flowers, which have been developed to suit the taste of insects. For example, there is no family of plants which contains a greater number of fruity seeds than the rose tribe, in which are comprised the apple, pear, plum, cherry, blackberry, raspberry, strawberry, quince, medlar, loquat, peach, apricot, and nectarine, besides the humbler hips, haws, sloes, and common hedge-fruits, which, though despised by lordly man, form the chief winter sustenance of such among our British birds as do not migrate to warmer climates during our chilly December days. Now, no trace of the rose tribe can be discovered until Miocene times; in other words, no fruit-bearers appear before the evolution of the fruit-eaters who called them into existence; while, on the other hand, the rapid development and variation of the tribe in the succeeding epoch shows how great an advantage it derived from its tendency to produce edible seed-coverings.

But not only must these coverings be succulent and nutritious; they must also be conspicuous and alluring. For the attainment of these objects the fruit has recourse to just the same devices which had already been so successfully initiated by the insect-fertilised flowers. It collects into its pulpy substance a quantity of that commonly-diffused vegetable principle which we call sugar. Now sugar, from its crystalline composition, is peculiarly adapted for acting upon the exposed nerves of taste in the tongues of vertebrates; and the stimulation which it affords, like all healthy and normal ones, when not excessive in amount, is naturally pleasurable to the excited sense. Of course, in our own case, the long habituation of our frugivorous ancestors to this particular stimulant has rendered us peculiarly sensitive to its effects. But even from the first, there can be little doubt that a body so specially fitted to arouse sensation in the gustatory nerve must have afforded pleasure to the unspecialised palates of birds and rodents; for we know that even in the case of naturally carnivorous animals, like dogs, a taste for sugar is extremely noticeable. So then the sweet juices of the fruit were early added to its soft and nutritive pulp as an extra attraction for the animal senses.

But the greatest need of all, if the plant would succeed in enticing the friendly parrot or the obsequious lemur to disperse its seed, is that of conspicuousness. Let the fruit be ever so luscious and ever so laden with sweet syrups, it can never secure the suffrages of the higher animals if it lies hidden beneath a mass of green foliage, or clothes itself in the quiet garb of the retiring nut. To attract from a distance the eyes of wandering birds or mammals, it must dress itself up in a gorgeous livery of crimson, scarlet, and orange. The contrast between nuts and fruits is exactly parallel to the contrast between the wind-fertilised and the insect-fertilised flowers. An apple-tree laden with its red-cheeked burden, an orange bough weighed down with its golden spheres, a rowan or a holly bush displaying ostentatiously its brilliant berries to the birds of the air, is a second edition of the roses, the rhododendrons, and the maythorns, which spread their bright petals in the spring before the fascinated eyes of bees and butterflies. Some gay and striking tint, which may contrast strongly with the green foliage around, is needed by the developing fruit, or else its pulpiness, its sweetness, and its fragrance will stand it in poor stead beside its bright-hued compeers.

How fruits began to acquire these brilliant tints is not difficult to see. We found already, in the case of flowers, that all external portions of a plant, except such green parts as are actually engaged in assimilating carbon under the influence of solar energies, show a tendency to assume tints other than green. This tendency would, of course, be checked by natural selection in those seeds which, like nuts, are destroyed by animals, and so endeavour to escape their notice; while it would be increased by natural selection in those seeds which, like fruits-proper, derive benefit from the observation of animals, and so endeavour to attract their attention. But it is noticeable that fruits themselves are sour, green, and hard during their unripe stage, that is to say, before the seeds are ready to be severed from the mother-plant; and that they only acquire their sweet taste, brilliant colour, and soft pulp just at the time when their mature seeds become capable of a separate existence.

The connection of these changes with the process of oxidation is far more certain and more marked in the case of fruits than in that of flowers. During their early state, pulpy fruits have the structure and chemical composition of leaves. But as they mature, they gradually pass through the acid stage, and finally reach that of ripening, when their gum, their cellulose, and their acids are partially converted into sugar. These alterations are accompanied by "a loss of watery fluid, a slight increase of temperature, and an evolution of carbonic acid." "Saussure and Couverchel state that grapes, apples, and pears, when separated from their respective plants, and kept at a temperature of about 60° F., gave out carbonic acid. Fremy found that ripe fleshy fruits gave out a large quantity of carbonic acid when boiled in a saline solution.[1] Berard thinks that these changes in fruits depend essentially on the action of the oxygen of the air. Fleshy fruits, he says, may be preserved with little alteration for many weeks in vacuo, in nitrogen, and in hydrogen gas; peaches, plums, and apricots may be kept from twenty to thirty days, and pears and apples for three months, in a sealed bottle containing a little sulphate of iron, lime, and water, which remove the oxygen of the air. Fremy found that the ripening of the fruit was arrested by covering it with varnish, which he supposes to act partly by preventing the access of air, and partly by stopping the transpiration, and thus checking the flow of sap into the fruit." [2]

It may also be added that here, as in the case of flowers, an original tendency towards colouration in seed-coverings, quite apart from any selective action, may be distinctly noted. Not only are the spore-cases of many mosses prettily tinted with pink or yellow, but the fruits of many flowering plants which have no succulent pulp yet exhibit a decided turn for coloured juices. Instances may be found in the dock, and less markedly in almost all capsuled fruits. But with fruits, as with flowers, we may say roughly that all the bright-coloured species depend

[1] Fremy, "Recherches Chimiques sur la Maturation des Fruits," in "Comptes Rendus," xix. 784.

[2] Balfour's Class-Book of Botany, pp. 604, 606.

for their diffusion upon animals, while all those which do not depend upon animals are dull. "The smaller plants," says Mr. Wallace, "whose seeds simply drop upon the ground, as in the grasses, sedges, composites, umbelliferæ, &c., always have dry and obscurely-coloured capsules, and small brown seeds. Others, whose seeds are ejected by the bursting open of their capsules, as with the oxalis and many of the caryophyllaceæ, scrophulariaceæ, &c., have their seeds small, and rarely or never edible."[1]

In the case of the attractively coloured fruits, however, Mr. Wallace points out that the actual seeds are of such a nature as to escape destruction when the fruit itself is eaten. "They are generally very small and comparatively hard, as in the strawberry, gooseberry, and fig; if a little larger, as in the grape, they are still harder and less eatable; in the fruit of the rose (or hip), they are disagreeably hairy; in the orange tribe, excessively bitter. When the seeds are larger, softer, and more edible, they are protected by an excessively hard and stony covering, as in the plum and peach tribe; or they are enclosed in a tough horny core, as with crabs and apples. . . . These fruits may also be swallowed by some of the larger frugivorous birds; just as nutmegs are swallowed by pigeons for the sake of the mace which encloses the nut, and which, by its brilliant red colour, is an attraction as soon as the fruit has split open, which it does upon the tree."[2]

But exactly as we saw that some flowers attract insects by a delusive hope of honey where no honey is really to be had, so do some fruits hold out attractions of colour to birds or mammals where little or no food is to be had in return. Thus many beans have beautiful coverings, which must be purely deceptive in their nature for though some animals may perhaps be able to eat them, yet these can be of no benefit to the plant, and it cannot

[1] Tropical Nature, p. 227. [2] Ibid., p. 226.

be for their sake, therefore, that the bright integument has been developed. An extreme case is that of the hard little rosary bean (*Abrus precatoria*), so well known as the seed from which the prisoners in Cayenne manufacture their pretty ornaments. "It may be," says Mr. Wallace, "that birds, attracted by the bright colour of the seeds, swallow them, and that they pass through their bodies undigested, and so get dispersed." If so, the ingenious naturalist suggests that the device may only succeed with "young and inexperienced birds." I am myself inclined to think, however, that some plants, such as our English cuckoo-pint and the famous West Indian manchineel, actually derive a benefit from their poisonous properties; because if eaten by birds or small mammals, they might destroy their host, and the seeds would thus have an opportunity of germinating in the midst of a rich manure-heap, consisting of its decomposing body.

Another analogy with entomophilous flowers may be found in the very variable nature of the pulpy and coloured substance. It does not matter at all what portion of the seed-covering or its adjacent parts happens first to show the tendency towards succulence, sweetness, fragrance, and brilliancy. It serves the attractive purpose equally well whether it be calyx, or stalk, or skin, or receptacle. Just as in the case of flowers, we found that the coloured portion might equally well consist of stamens, petals, sepals, bracts, or spathe, so, but even more conspicuously in the case of fruits, the attractive pulp may be formed of any organ whatsoever which exhibits the least tendency towards a pulpy habit, and an accumulation of saccharine deposits.

Thus, in the pomegranate, each separate seed is enclosed in a juicy testa or altered shell; in the nutmeg and the spindle-tree, an aril, or purely gratuitous coloured mass, spreads gradually over the whole inner nut; in the plum and cherry, a single part, the pericarp, divides itself into two membranes, whereof the inner or protective coat is hard and stony, while the outer or attractive coat is soft, sweet, and bright coloured; in the strawberry, the receptacle, which should naturally be a mere green bed for the various seed-vessels, grows high, round, pulpy, sweet, and ruddy; in the rose, the fruit-stem expands into a scarlet berry, containing the seed-vessels within, which also happens in a slightly different manner with the apple, pear, and quince; while in the fig a similar stem encloses the innumerable seeds belonging to a whole colony of tiny blossoms, which thus form a compound fruit, just as the daisy head, with its mass of clustered florets, forms a composite flower. Strangest of all, the common South American cashew tree produces its nut (which is the true fruit) at the end of a swollen, pulpy, coloured stalk, and so preserves its embryo by the vicarious sacrifice of a fallacious substitute. These are only a few out of the many ways in which the selective power of animals has varied the surroundings of different seeds to serve a single ultimate purpose.

Nor is any plan too extravagant for adoption by some aberrant species. What seed-organ could seem less adapted for the attraction of animals than a cone like that of pines and fir-trees? Yet even this hard, scaly covering has been modified, in the course of ages, so as to form a fruit. In the cypress, with its soft young cones, we can see dimly the first step in the process; in the juniper, the cone has become quite succulent and berry-like; and finally, in the red fruit of the yew, all resemblance to the original type is entirely overlaid by its acquired traits.

Equally significant is the fact that closely allied species often choose totally different means for attracting or escaping observation. Thus, within the limits of the rose tribe itself we get such remarkable variations as the strawberry, where the receptacle forms the fruit; the apple, which depends on the peduncle, or swollen stalk, for its allurement; the raspberry, where each seed-vessel of the compound group has a juicy coating of its own, and so forth; while, on the other hand, the potentilla has no fruit at all, in the popular sense of the word; and the almond actually diverges so far from the ordinary habits of the tribe as to adopt the protective tactics of a nut. Similarly, in the palm tribe, while most species fortify themselves against monkeys by extravagant hardness, as we see in the vegetable ivory, and the solid coquilla nuts from which door-handles are manufactured, a few kinds, like the date and the doom-palm, trust rather to the softness and sweetness of their pulp as aids to dispersion. The truth which we learn from these diverse cases may be shortly summed up thus: Whatever peculiarities tend to preserve the life of a species, in whatever opposite ways, equally aid it in the struggle for life, and may be indifferently produced in the most closely related types.

I have given this large amount of space to the consideration of fruits, because I believe we can hardly overestimate their importance in quickening the colour-sense of the higher animals, and, above all, in settling the æsthetic tastes of birds, quadrumana, and men. We are apt to forget how considerable an element in the total coloured environment of forestine animals is formed by brilliant fruits. The utilitarian connection of fruits generally has made us cultivate them more for their pulp and sweetness than for their beauty, and in many cases they have actually lost in colour under cultivation; while flowers, being selected entirely for their visual attractiveness, have gone on developing more and more expanded masses of bright petals.[1] But if we look at a few striking instances, we shall find that fruits almost equal in native beauty their earlier rivals, the entomophilous blossoms. Among cultivated varieties commonly grown in Britain, we may take apples, plums, peaches, cherries, grapes, strawberries, raspberries, currants, and pumpkins; while it may be worth while to remind the reader that

[1] See this point further elucidated in Chapter XII., on the Æsthetic Value of Colour.

certain other fruits or seeds, which usually appear on our tables in a green state, like cucumbers and scarlet-runner beans, have brilliant coats in their mature forms. Amongst English wild fruits, sufficient examples will be found in the hips, haws, hollyberries, mistletoe, sloe, mountain ash, barberry, yew, juniper, ivy, spindle-tree, arum, blackberry, iris, saffron, elder, and sea-buckthorn. The tropics and sub-tropical climates, however, supply us with far more gorgeous examples in their oranges, shaddocks, lemons, mangoes, star-apples, pomegranates, capsicums, bananas, nutmegs, achees, egg-fruits, prickly pears, tomatoes, winter cherries, solanums, dates, and passion-flower berries. In fact, we may say that fruits-proper exhibit larger amounts of brilliant colouration than any other class of organic objects except entomophilous flowers.

CHAPTER VII.

THE COLOUR-SENSE IN VERTEBRATES.

ALTHOUGH the perception of colour by birds and mammals has been taken for granted in the preceding chapter, and although it is practically all but incontestable that the higher vertebrates are quite as fully endowed in this respect as ourselves, yet the positive proofs which can be advanced in favour of the belief are very meagre and insufficient. The only real evidence is that supplied by our every-day observation, but no person familiarly acquainted with the habits of birds and mammals ever doubts for a moment their essential agreement with ourselves so far as concerns the visual faculties. Nevertheless, it may be well to point out the few positive facts which are forthcoming on the subject, connecting them at the same time with the probable genesis of the developed sense.

Apparently the perception of colour is inherited by the whole vertebrate series from some earlier common ancestor. At any rate, considerable traces of the colour-sense may be detected among many marine invertebrates. The best known instance is that of the chameleon shrimp (*Mysis chamæleo*), which has the power of altering its own colour in correspondence with the material among which it is found. When lying on a sandy bottom it appears grey; but when lurking among seaweed, it is green or reddish brown, according to the nature of the background. This change is produced by means of a reflex action connected with the eye, for when the animal is blinded it no longer occurs. In other words, we must suppose that when the optic nerve of the shrimp is affected by the green light from a piece of seaweed, certain muscles are set in action, voluntarily or automatically, which cause a corresponding change in the arrangement of the pigment cells, so that the animal appears green itself. It may be added, too, that this peculiarity affords an indirect proof of a colour-sense in the enemies of the chameleon shrimp (which cannot be more highly developed animals than fishes, and may perhaps by other crustaceans); because the creature can only possess this power for the sake of escaping the observation of its foes. If we believe it to be so provided for the purpose of deceiving its prey, then we must allow the existence of colour-perception even in more lowly forms on the average than fishes or crustacea.

Indeed, the brilliant nature of many marine animals and plants affords an excellent opportunity for the development of a colour-sense. Instead of the uniform green of the forest, with the dingy black or brown of soil and rocks, we have here the exquisite colours of sea-anemones, starfish, corals, serpulæ, jellyfish, callianiridæ, aphroditidæ, ascidians, sea-slugs, and shell-covered mollusca, which browse amid groves of variegated algæ, whose hues are far more diversified than those of terrestrial vegetation. Amongst such surroundings it would almost be impossible that a colour-sense should not take its rise; and many indirect proofs conspire to show that in the class of fishes at least it exists in high perfection.

The most striking evidence is that afforded by certain flat-fish, which, like the chameleon shrimp, possess the power of changing their colour, so as to suit the bottom upon which they lie. Here again the peculiarity not only shows that the fish themselves are differentially affected by the various colours, but also that their enemies or prey are conscious of similar differences, or else the disguise would be useless.

Equally significant is the colouration of the common sole, brill, dab, and flounder. Any person who has seen these fishes lying on a natural bottom or in an aquarium must have been struck by the perfection of the imitation, which often baffles even human eyes, in spite of the actual knowledge that a fish is somewhere to be found upon the spot.

In like manner, the fishes, mollusca, and crustaceans which inhabit the sargasso weed, are all protectively coloured of exactly the same pale buff hue as the sargasso itself. One may often closely examine a piece of the weed, freshly brought up in a bucket of sea-water, and yet fail to detect any sign of life, until the attempt to raise the weed from the water reveals the fact that some small crabs or tiny fishes are lurking unseen among its waving branches. In all such cases, the existence of the imitative colouring is fair proof that it subserves the good of the species by protecting its members against enemies, or enabling them more readily to secure their prey.

Perhaps the only direct evidence, however, is that of the baits used by fishermen. Mackerel and other fish are often taken by means of red rags. A spoon painted bright scarlet forms a capital trolling bait. All anglers are agreed that trout can discriminate between the various imitation flies offered to their notice, and that the original colours must be carefully copied. Indeed, the facts rather tend to show, not only that fishes can discriminate colours, but also that they are attracted by metals or other brilliant objects, and by pure or intense hues. A taste for colour as well as a mere neutral perception seems to be implied by these observations.

Those who have given the greatest attention to the subject are inclined to credit fish with a very high degree of colour sensibility; and their opinion may be set down here as having some weight in so uncertain a subject. Mr. H. N. Mosely, the accomplished naturalist of the *Challenger* expedition, believes that almost all the colours of marine animals have been acquired for purposes of warning, protection, or attraction of prey, and that they have special reference to the eyes of fishes and higher crustaceans.[1] The whole colouration of the lower aquatic organisms is exactly what we should expect it to be if the more highly evolved marine creatures were possessed of a colour-sense; and it is quite inexplicable and gratuitously complex if we suppose them to be destitute of such a faculty. Mr. Darwin is further of opinion that the colours of many fishes have been produced by the action of sexual selection; and though I do not mean to treat this part of our subject in detail till a later chapter, I think the conclusion of so careful and masterly an observer has considerable substantive value as corroborative of the positive facts.

When we proceed to examine the amphibia, much better evidence is available. The two colours green and blue are the least markedly different of all hues; and if they can be discriminated from one another by any species, we may be sure that that species possesses a very perfect form of colour-sense. Kühne of Heidelberg, in the course of certain researches on the nature and functions of retinal purple, discovered that if a number of frogs, *Rana esculenta* and *R. temporaria*, are confined in a shallow dish, one half of which is covered with green glass and the other half with blue, they will shortly all collect under the green portion. Great care was taken to eliminate all disturbing elements, such as unequal transparency to heat (diathermancy), or unequal intensity of illumination, and it was conclusively ascertained that an enormous majority of the frogs exhibited a distinct preference for the colour green over the colour blue. Blind frogs introduced into the same vessel showed no preference for one part over another.[2] In this case, again, it is interesting to note that a special emotional taste, as well as an intellectual

[1] Quarterly Journal of Microscopical Science, New Series, vol. xvii. pp. 19, 22.

[2] Untersuch. aus dem Physiol. Institut in Heidelberg, Band i. Heft 2.

discrimination, is proved by the facts; and this taste becomes particularly interesting from the point of view of sexual selection, when we remember that green forms a very common colour amongst the *Ranidæ*.

Frogs likewise possess the power of changing their colour in correspondence with the environment, in the same manner as already noted in *Mysis*.[1]

Reptiles also show some distinct marks of colour-perception. The most familiar instance is that of the chameleon, whose natural hue is a muddy white, changing with the nature of the background to yellow, brown, green, or bluish grey. The mechanism by which this change is effected has met with full treatment at the hands of Von Wittich.[2] Two layers of pigment cells are deeply seated under the skin, consisting of blue and yellow colouring matter respectively; and by forcing up one or other of these layers through muscular pressure, the animal assumes a bluish or yellowish tint, while the green is produced by simultaneous pressure upon both layers. In this manner the chameleon is able to simulate the appearance of the branches or leaves on which it stands, and so, perhaps, both to escape enemies and deceive prey. As before, the power of changing colour implies impressibility both in the animal itself and in certain other species for whose deception the habit has been acquired. The action is undoubtedly reflex, and ceases if the eyes be covered.

Many of the insects which mimic leaves or other like objects in the environment have probably gained this means of protection to escape the notice of lizards and other reptiles. But as the mimetic resemblance is oftener useful for deceiving birds, we may more fitly consider these cases when we pass on to examine the colour-sense in the higher vertebrates. There are one or two instances

[1] Pouchet, Comptes Rendus, xxvi. 575, and Lister, Phil. Trans., 148, p. 627.

[2] Proc. Vienna Imperial Acad. Nat. Sci., vol. iv., and Müller's Archiv., 1854.

of protective colouring, however, which evidently have reference to the reptilian eye alone. Mr. Bates mentions a South American snake (*Dryophis fulgida*), whose pale green body exactly resembles the stem of a liana, and even imposed upon the keen-eyed naturalist himself at first sight. The prey for which this living branch lies in wait consists of tree-frogs and lizards.[1] These, themselves, in turn, may perhaps escape it by their own prevailing greenness, which makes them so difficult of detection amongst the foliage on which they rest. Again, Sir Joseph Hooker found three ticks on an Indian lizard, each of which was coloured in imitation of that part of its host's body on which it preyed. One from the yellow belly was yellow; one from the brown head was brown; and one from the parti-coloured scales was parti-coloured, "the hues corresponding with the individual scales which they covered."[2] Here we can hardly suppose that the imitation could be of any use except as a protection against the lizard himself and the other members of his family.

It may be worth while to mention in passing that many lizards besides the chameleons possess the power of changing their colour by inflating their lungs, which compresses or spreads the layers of pigment cells.[3] The sexual colours of the beautiful *Draco* and other reptiles have been fully described by Mr. Darwin. "The shining appendages of the throat," says Dr. Günther, "are merely folds of the skin, ornamental and sexual. Such appendages always betray an excitable temper," or, in other words, co-exist with strong sexual jealousies. The significance of these facts will become more apparent when we pass on to the general question of selective preference for decorated mates.

Among birds, the perception of colour is shown by a

[1] The Naturalist on the Amazons, p. 99.

[2] Himalayan Journal, vol. i. p. 37.

[3] Günther, Reptiles of British India, p. 56.

large number of facts, collected by Mr. Darwin.[1] A tame partridge described by Mr. Hussey "seemed fond 'of gay colours, and no new gown or cap could be put on without catching his attention.'"[2] Lord Lilford notices that the ruff "will dart down to a bright-coloured handkerchief, regardless of repeated shots."[3] The well-known bower-bird "collects gaily coloured articles, such as the blue tail-feathers of parrakeets, bleached bones, and shells." Mr. Gould "found in one bower a neatly worked stone tomahawk and a slip of blue cotton." "The regent-bird, as described by Mr. Ramsay, ornaments its short bower with bleached land-shells belonging to five or six species, and with berries of various colours, blue, red, and black, which give it when fresh a very pretty appearance. Besides these, there were several newly picked leaves and young shoots of a pinkish colour, the whole showing a decided taste for the beautiful."[4]

To these facts, which bear evidence to taste as well as perception, we may add the antipathy of the turkey-cock to scarlet, which is probably an effect of sexual jealousy, as the red would be ancestrally associated in his mind with the wattles of a rival. "The recognition of colour by small birds generally," says a late writer,[5] "is indisputable. Every one must have observed with varied feelings the discrimination with which they select the 'sunny side' of a pear, a plum, or a peach. It is also an established fact that they will attack the red currant in preference to the white variety, though the latter is much the sweeter of the two. Many observers during the last few years have pointed out how the yellow crocus is torn to pieces by sparrows and other birds, while the white and other varieties are unmolested." I have myself often

1 The Descent of Man, vol. ii. p. 110.

2 The Zoologist, 1847–48, p. 1602, quoted in Darwin, *ubi supra.*

3 "The Ibis," vol. ii. p. 344, 1860.

4 Gould, Handbook to the Birds of Australia, 1865, vol. i. pp. 444–461; and Ramsay, in "The Ibis," 1867, p. 456, quoted in Darwin, *ubi supra.*

5 "The Senses of the Lower Animals," in the Quarterly Journal of Science, July 1878.

noticed in Jamaica the unerring certainty with which chickens darted from blossom to blossom of a yellow potentilla, for which they have a particular fancy, and which they always snapped up as though they supposed it to be alive.

These instances lead us on to those of the fruits, whose development we examined in our last chapter. "Red," says Mr. Wallace, "being a very common colour of ripe fruits which attract birds to devour them and thus distribute their seeds, we may be sure that the contrast of red and green is to them very marked."[1] But this seems to me a somewhat inadequate expression of the real evidence on the point. We have seen that almost all those seeds or fruits which would be injured by the interference of birds are protectively coloured green or brown, while almost all those seeds or fruits which would be aided by the interference of birds are attractively coloured red, pink, orange, yellow, purple, blue, lilac, or black. I think these facts fully justify us in concluding that birds are able to distinguish every one of these colours from green, and most likely from one another. Otherwise there would be no reason why succulent fruits should differ in colour from nuts. The single case of the almond and the plum will bring the question at issue into strong relief. As in the case of entomophilous flowers, so in the case of succulent fruits, unless we believe that the seemingly attractive organs were developed for the purpose of enticing animals, we must believe that they are a positive waste of energy to the parent plant.

The evolution of bright flowers themselves shows that birds as well as insects are attracted by their beautiful petals. Mr. Darwin has collected many instances in which blossoms are fertilised by birds; and Fritz Müller notes several species of *Abutilon* in Brazil, which he believes depend entirely on humming-birds for the dispersion of their pollen.[2] Mr. Wallace observes that brilliant

[1] Tropical Nature, p. 246. [2] Cross-Fertilisation, p. 371.

flowers with handsome corollas exist in many Oceanic islands, such as Juan Fernandez, where flying insects are almost unknown; but their place is supplied by humming-birds, which Mr. Mosely mentions as being "extraordinarily abundant."[1] Mr. Belt believes that a climbing plant of Central America, *Marcgravia nepenthoides*, has been specially adapted to the same birds; while Mr. Wallace thinks that many Australian and Malayan flowers have been similarly specialised for the visits of honey-eaters, lories, and sun-birds. "Only large flowers," says Mr. J. E. Taylor, "can be visited by these birds, or those whose polypetalous corollas allow of the head being thrust into the centre. Hence we have, in some measure, a reason afforded us for the larger size of the flowers in regions where such birds are abundant. The large bushes and trees of such countries usually bear very fine showy flowers in order to attract the birds; and it is found that the brush-tongued parrakeets are particularly fond of the flowers which grow at a height above the ground."[2] Any one who has watched a humming-bird darting with lightning speed from blossom to blossom could hardly have a doubt of his acute colour-perception.

The proofs afforded by imitation and mimicry are stronger in the case of birds than of any other class. One may say generally that almost all insects which display protective or imitative colouring do so for the sake of escaping birds or lizards. A few cases must suffice to show the general tendency of the evidence. The leaf and stick insects (Phylliidæ and Phasmidæ) closely imitate the colours and shapes of leaves and sticks. One in particular, the *Ceroxylus laceratus*, is apparently overgrown by moss or jungermannia.[3] Sir Emerson Tennent describes the

[1] Tropical Nature, p. 273.

[2] Flowers, their Origin, &c., p. 294. This is the only instance in which I have availed myself of new matter from this interesting little volume, which appeared while I was in course of revising my manuscript; but the omission would have been a serious defect; so I have here departed from my usual rule, and taken most of the above cases from Mr. Taylor's pages.

[3] Wallace, Contributions to the Theory of Natural Selection, p. 64.

leaf-insects as possessing "all varieties of hue, from the pale yellow of an opening bud to the rich green of the full-blown leaf and the withered tint of decay."[1] The *Kallima paralekta*, a leaf-like butterfly of the Malay Archipelago, always rests among dead or dry leaves, which it resembles in all their varying hues, even appearing to be spotted with small fungi. Canon Tristram has noted that almost every insect, bird, or reptile inhabiting the desert of Sahara is coloured exactly like sand,[2] and Lord George Campbell mentions a butterfly similarly imitative of its background which frequented the sea-shore at Amboyna.[3] A South American *Leptalis* so closely resembles an uneatable *Ithomia* "in every shade and stripe of colour," that Mr. Bates could hardly distinguish them, even with the aid of his minute entomological knowledge. "One of the Hemiptera (*Spiniger luteicornis*)," says Mr. Belt, "had every part coloured like the hornet (*Priocnemis*) that it resembled. In its vibrating coloured wing-cases it departed greatly from the normal character of the Hemiptera and assumed that of the hornets."[4] The same careful observer gives many similar instances of mimetic resemblance in the Coleoptera,[5] and Lepidoptera.[6] But perhaps the most astonishing of these imitative forms is that of a moss-like insect, the larva of a *Phasma*, which is prolonged into curious green filaments, to mimic the moss in which it lives.[7] Of course these creatures could derive no advantage from their minute reproduction of spots, lines, and hues, unless the enemies against which they required protection were capable of distinguishing their colours.

Mimicry or imitative devices of this sort are not confined to insects. Many lizards, such as the geckos, have colours like those of the walls on which they creep; while the

[1] Ceylon, p. 251.

[2] See also Gurney, Rambles of a Naturalist, p. 56.

[3] Log-letters from the *Challenger*, p. 208. Although this amusing writer can hardly be considered a scientific authority, he may be confidently relied on for any question of fact.

[4] The Naturalist in Nicaragua, p. 319.

[5] Ibid., p. 317.

[6] P. 382.

[7] Figured in Belt, *ubi supra*, p. 382.

protective green hue of the tree-frogs has already been noticed. Even birds occasionally mimic one another in the same manner. For example, two species of *Mimeta* (a sort of oriole), in Bouru and Ceram, imitate two *Tropidorhynchi* (honeysuckers) in minute details of colour, thus escaping small birds of prey, as the *Tropidorhynchi* are strong and pugnacious creatures.[1] For other cases the reader must be referred to Mr. Wallace's admirable essay on "Mimicry and other Protective Resemblances among Animals."

These various proofs, though indirect, can leave us in little doubt with regard to the general existence of a colour-sense among birds.

When we come to the highest class of vertebrates—the mammalia—strangely enough the evidence of a colour-sense almost entirely fails us. The antipathy of male ruminants for scarlet, and the curiosity which certain monkeys display with regard to bright-coloured objects, are the only facts in point which come under ordinary observation. This result, so contrary to what we might have expected, appears really quite natural when we examine more closely the circumstances of the case. By far the larger part of the mammalia are either herbivorous like the ruminants and pachyderms, or carnivorous like the technical carnivores, insectivores, and whales. Only a small portion of the class subsists upon fruits, while none of them are very specially connected with flowers. Hence a large set of possible tests which we can employ in the case of insects and birds are wholly inapplicable to mammals. Moreover, the want of close relations with the coloured parts of plants has probably resulted in a want of any peculiar love for bright colour, such as we see reason to suspect in the butterflies, humming-birds, and parrots. This absence of a taste for brilliancy is probably marked by the absence of brilliant hues in the animals themselves, the result of sexual selection; for these hues,

[1] Wallace, Malay Archipelago, p. 401.

as we shall see hereafter, only appear among the mammalia in a few higher arboreal and frugivorous species, such as the mandrill and certain squirrels. For the most part, throughout the mammalian series sexual selection seems only to have exerted itself, if at all, in the production of elegant shapes, protuberances like horns and dewlaps, and marked contrasts of light and shade, as in the zebra, giraffe, and hyæna.

Nevertheless we can hardly doubt that mammals do possess a considerable colour-sense, though, owing to the circumstances of their practical environment, their taste for any special hue is probably far from strong.

Here once more I must remind the reader that the proofs of a colour-sense throughout the whole infra-human world are necessarily very derivative, and that they owe their chief strength to their cumulative character. The fragmentary evidence collected in this chapter will be much corroborated and supplemented by that which will be detailed in the sequel. Enough will have been done if we succeed in showing that the hypothesis of a general colour-sense is consonant with all the facts of nature, and helps us to understand those facts in a way which no other hypothesis can do. For the present it will be sufficient if we bear in mind the one great point hitherto settled—that wherever any part of a plant, be it flower or fruit, will derive any benefit from attracting the eye of an animal, be it insect, bird, or mammal, that part is almost invariably coloured with some pure and brilliant hue, be it blue, red, yellow, pink, orange, violet, or lilac, quite distinctive from the green of ordinary vegetation. This one fact is the great pivot upon which turns our whole knowledge of the animal colour-sense.

CHAPTER VIII.

THE COMMUNITY OF TASTE BETWEEN FLOWER-FEEDING AND FRUIT-EATING SPECIES.

Before we proceed to consider the secondary reactions of the colour-sense in insects and vertebrates upon their own external appearance, we must glance for a moment at one of the determining causes which give approximate uniformity to the general results of such reactions in the animals with which we are most specially concerned. In the next chapter we shall have to examine the production of bright hues in the wings of butterflies, the skins of lizards, the feathers of birds, and the fur of mammals, due to the selective action of sexual preferences. But, as a necessary preliminary to that inquiry, we must first set ourselves to determine the principles which govern the formation of tastes generally among the flower-feeding and fruit-eating animals. Before we can trace to its final effects the action of a sexual preference for bright colouring, we must previously find out with certainty the reasons why a taste for such colouring should exist at all in the animal consciousness.

People are generally too apt to accept as ultimate and obvious every fact with which they have always been familiar. Seeing that bright colours as a rule attract children and savages, dogs, birds, fish, and insects, they do not trouble themselves to seek a reason for this preference, but take it for granted as an inherent and natural property of the animal organism, or, more often and more absurdly still, of the colours themselves. If, h reflect upon the subject for a moment, we shall see that there is no primitive and self-sufficing reason in the nature of things why any one colour should be more beautiful to us than another. Dull and dingy hues might conceivably have been just as pleasant to our sense, under slightly different conditions of our development, as we know bright and pungent hues to be, under the actual circumstances of humanity. We must get a little deeper into the groundwork of our likes and dislikes if we would really understand the origin of our native preference for brilliant tints over mixed or unstimulating colours.

Now, after this preamble, most readers will imagine that I mean to explain the liking of flower-feeders and fruit-eaters for bright hues by means of that grand but somewhat vaguely employed shibboleth, the Association Theory. I know that to the mass of loose thinkers association is a sort of psychological *deus ex machina* which satisfactorily accounts for every ill-defined mental problem, just as electricity is a sort of physical *deus ex machina* which similarly gets over every ill-comprehended material problem. Such persons say to themselves at once, "Oh, of course, birds and butterflies feed off bright-coloured objects; so bright colours get associations with their food, and are consequently pleasant to them." Having thus satisfied their nascent critical doubts by the easy application of an accepted formula, they never pause to translate their vague speculation into thinkable terms, but leave it as they took it up, a mere algebraical expression, incapable of rational statement in a concrete form. For how can association with food make a colour or anything else pleasant in itself? This is the true crux of the Association Theory, a crux which, as I humbly believe, few of its adherents have ever perceived in its full significance. Until it has been solved, the theory remains a mere verbal explanation, adding nothing to our real knowledge of the subject, yet deluding us by its specious resemblance to an explanatory truth.

The mode of exposition here adopted will be a very different one, based upon the known psycho-physical law of pleasure and pain. According to that law, pleasure is the psychical aspect of an ultimate physiological fact, which in its physical aspect may be summed up as the unimpeded activity of a fully nurtured and not overworked nervous structure in unbroken connection with the cerebro-spinal or other central sentient system. Conversely, or nearly so, pain is the psychical aspect of an ultimate physiological fact, which in its physical aspect may be summed up as the disintegration, insufficient nutrition, or excessive activity of a nervous structure, similarly connected with the sentient organism.[1] With the latter half of this important law we have here little or nothing to do; but the former half so intimately concerns our subject that I shall make no apology for endeavouring briefly to explain its meaning in simpler language than that of the above abstract formula.

A pleasure, then, is the feeling which results when any sentient nervous centre receives a stimulation not excessive in quantity, nor beyond the existing power of the structures concerned. Every centre undergoes at each stimulation a certain amount of disintegration; and if that disintegration pass beyond the easy repairing-point of the system, pain sets in. But, on the other hand, so long as the stimulation is moderate, by exercising the structures it promotes their general efficiency, and hence it is accompanied by a feeling of pleasure. Or to translate our law into still more concrete and ordinary language, we may say that whenever an organ which can feel at all is exercised not beyond the due amount, pleasure is the result. Hence the pleasurableness of any activity may be accepted as a rough gauge of its general desirability for the organism as a whole, while conversely its painfulness

[1] For a full explanation of the form here given to this law (originally due to Mr. Herbert Spencer and Professor Bain, working on the basis of previous inquirers, from Aristotle downwards), see my "Physiological Æsthetics," chap. ii., "Pleasure and Pain," where the grounds upon which the conclusion is based have been detailed at length.

may be regarded as a certain proof of its general undesirability.

Now the more fully-nurtured an organ may be, the higher is its functional efficiency, and the greater the pleasure to be derived from its exercise. We all know that the fresher our limbs, our muscles, our nerves, and our eyes, the greater the enjoyment we derive from a country walk or a game of cricket. After long fasting we eat our food with greater relish; after long confinement we use our legs and arms with redoubled delight. But we also know that in order to keep up a state of high efficiency in any organ, frequent exercise is necessary. Only by running, jumping, rowing, and gymnastics can we bring our muscles into a proper condition for hard athletic work. Only by constant practice can we retain any accomplishment which we have learnt by dint of serious effort. And just the same is true of nerves. Their existing structure has been acquired by continuous function in past generations, and continuous function is necessary still if we would prevent them from rusting into obsolescence.

Accordingly, whenever we find that any activity is productive of immediate pleasure in ourselves, we may be sure that the activity in question is one which has long been practised by our human or ante-human ancestors. The greater the pleasure, as I have elsewhere endeavoured to show, the greater the intimacy of connection between the activity and the life of the species. Let us, for example, take the case of colour itself, with which we are here so fully engaged. If in any species the need for distinguishing different colours ever arose, and if by its side there also arose a nascent structure for so distinguishing them, then those individuals in which that structure was most fully developed would survive from generation to generation, in virtue of their superior adaptation to the needs of their environment above their less highly endowed compeers. But with each such increment in the structure there would go increased pleasure in the function. Conversely, the more fully the function was indulged the more would the structure increase and strengthen by exercise. So from generation to generation, as the power of distinguishing colours became more and more developed, the pleasure arising from their perception would grow more and more acute. Such pleasure forms the first groundwork for that differential preference in individuals or species which we know as taste.

But every colour would not probably prove equally pleasurable. Some, like the ordinary greys, greens, and browns, occur too often in the surrounding world to allow of any marked gratification, derivable only from the intermittent stimulation of little-worked nerves. Moreover, these common colours would have no special reference to the life of the race, and so would have few structural connections with other portions of the central nervous system. But in the case of fruit-eating and flower-feeding species, we may well suppose that the special nerves devoted to the perception of red, yellow, orange, and purple would naturally be much strengthened by constant hereditary use; while the comparatively intermittent nature of the stimulation would render the accompanying feeling far more pleasurable than in the more familiar instances of green or brown. Furthermore, the close relation of these colours with the food of the species would doubtless give rise to numerous nervous connections in the central system, whereby the sight of such coloured objects might set up the necessary movements for obtaining the booty. In this manner the central organs of special colour-perception for the brilliant hues of fruits and flowers would in all probability assume unusually large dimensions, and would certainly possess large numbers of concurrent fibres along which waves of discharge might readily travel, thus giving free vent for a considerable volume of pleasure-yielding energy. Such species might fairly be said to possess a taste for red, yellow, and other like pungent hues; and we might accordingly give a rough defin of taste as a special preference, in an individual or a race, for one or more out of several similar objective stimuli, depending ultimately upon special variations of nervous development.

Of course this hasty definition leaves out of consideration the other half of the subject, which we might perhaps sum up as distaste,—the special repugnance to one or more among such stimuli, ultimately due to like diversities of individual or generic organisation. In this case, however, we must distinguish between two widely different forms of feeling, which are apt at first to be mentally confused,—mere neutral indifference, which results from a stimulation too languid or too common to produce pleasure, and positive dislike or disgust, which arises from some actually painful and disintegrative action. Thus, in sight, an ugly colour, like that of mud, is simply neutral and unstimulating; but in taste, a bitter or acrid substance probably sets up material disintegration, and so of course produces a positively painful sensation. This distinction will become more obvious and more important as we proceed.

In this way only, then, as it seems to me, can association have anything to do with the intrinsic pleasurableness of any sensation, namely, by affording outlets for the overflowing nervous energy. But the main pleasure of the sensation itself, as I understand the question, must be due to inherited calibre of the nerves and nervous centres employed, that calibre being due itself to ancestral function throughout many previous generations. To put once more the concrete case, fruit-eaters and flower-feeders derive pleasure from brilliant colours (postulating the fact for the time being, *argumenti gratia*), not because those colours have mental associations with their food, but because the structures which perceive them have been continually exercised and strengthened by hereditary use. The connection with food has given numerous outlets for the nervous energy, and has been the ultimate cause for the extra development of colour-perceiving structures, but it has had no direct effect, as I believe, upon the immediate pleasure of sensation.

It is true that in highly evolved animals, with whom the emotions have attained an immense and preponderant influence, associations do largely enter into all pleasurable feelings. But even here the ultimate explanation is equally simple and straightforward. These emotions have their own proper nervous seats, as Ferrier's experiments sufficiently show; and we must suppose that the actual sensation, being located in a centre which has connections with the seats of such emotions, rouses action in the emotional centres, more or less conspicuously, and so adds a more or less distinct factor to the total resulting consciousness. But it would be very foolish to transfer similar ideas into the simple nervous organisation of birds, and still more into that of bees and butterflies. Taste in these animals must be almost entirely a matter of direct sensation, dependent upon the calibre of the nerves employed, and little influenced by the few possible associated feelings.[1]

Having premised these few considerations as to the nature of taste in general, let us now go on to examine the special tastes of fruit-eating and flower-feeding animals. We shall find on investigation that these appear to be approximately identical throughout the whole animal series; while they are more or less strongly marked off from the opposite tastes of carnivores and carrion-eaters. The very same sweet and sugary substances, the very same etherial and delicate perfumes, the very same bright

[1] Lest any reader should imagine that I mean by these remarks to cast some doubt upon the whole body of Associationist Psychology, I hasten to add, parenthetically, that I fully accept that system so long as it confines itself to the relation between the senses and the intellect. It is only when it is brought forward as a verbal explanation of emotional facts that I begin to dissent; and even here my dissent, as will be seen from the above paragraph, extends only to the very simplest elements of feeling. I do not for a moment doubt that the æsthetic pleasures of cultivated Aryan man depend largely, or even mainly, upon associated emotion.

and dainty colours, seem pleasing in the very same way to butterflies, and humming-birds, and parrots, and apes, and men. The similarity of nervous impressibility which we thus perceive to hold throughout the whole heterogeneous collection of fruit and flower haunters casts much light upon the nature of sexual selection, and upon the identity of taste between man and so many lower animals. It enables us to see why the flowers which the bee developed for his own delight and guidance should be the joy of children and the envy of artists; why the hues of the orange and the mango should be as beautiful to man as to the toucans and macaws which gave them origin; why the wing of the butterfly, the tail of the peacock, and the burnished throat of the sun-bird should be exquisite to our eyes as they were to those of their fastidious mates; and why human beings should dye their bodies with the woad of Britain and the ochre of Papua, or tinge their garments with the purple of Tyre and the thousand hues of Lyon, to vie with the gorgeous tints of bird and insect in the very self-same profusion of refulgent colours.

First, then, let us begin with the sense of *taste*. It is a most noteworthy fact that wherever any part of a plant can gain any advantage by attracting the notice of animals, it always effects its purpose by the secretion of sugar, or, as we oftener though more incorrectly call it in this connection, honey. Now sugar, as I have already pointed out, has a special power of acting upon the gustatory nerves of animals, through the great solubility, diffusibility, and crystalline texture of its particles. Accordingly, we find that almost all classes of fruit-eaters and flower-feeders show a decided partiality for this pleasant stimulant—a partiality due, doubtless, to the long habits of their ancestors, which have developed correspondingly differentiated structures for the perception of the particular body in question. In flowers, sugar is secreted to attract bees and other insects; while in fruits, it acts as an allurement to birds and mammals. Furthermore, certain plants possess organs for the secretion of sugar on their stems or at the base of their leaf-stalks, of which Sir John Lubbock gives the following account:—"Belt and Delpino have, I think, suggested the true function of these extra-floral nectaries. The former of these excellent observers describes a South American species of Acacia, which, if unprotected, is apt to be stripped of its leaves by a leaf-cutting ant, which uses the leaves not directly for food, but, according to Mr. Belt, to grow mushrooms on. The Acacia, however, bears hollow thorns, and each leaflet produces honey in a centre-formed gland at the base, and a small sweet pear-shaped body at the tip. In consequence, it is inhabited by myriads of a small ant which nests in the hollow thorns, and thus finds meat, drink, and lodging all provided for it. These ants are continually roaming over the plant, and constitute a most efficient bodyguard, not only driving off the leaf-cutting ants, but even, in Mr. Belt's opinion, rendering the leaves less liable to be eaten by herbivorous mammalia."[1] Indeed, so universal is the taste for sugar among insects, that certain small animal creatures, like the Aphides and Cocci, have themselves acquired the habit of developing nectaries, and so gaining the protection of ants, which may be seen "assiduously running up the stems of plants to milk these curious little cattle." And if we want further proof of the general love for sweet food-stuffs, we need only bethink us how the insects flock about a barrel of treacle in our streets, how the birds congregate in fruit-gardens, and how our own children gather around the windows of the confectioner's shop to stare at the tempting wares within—rendered all the more enticing, be it observed, through the very same addition of red, blue, and yellow, which had already been invented by the fruit and the flower.

[1] "On Certain Relations between Plants and Insects," a lecture delivered at Glasgow, January 24, 1878, p. 6.

Equally significant are the changes in habit or mode of life between fruit-eating and flower-feeding classes. Thus, a large number of hymenopterous insects live upon honey extracted from flowers; but the omnivorous wasps, as we all know, have taken to surreptitious feasting upon the sugary juices of peaches, pears, and nectarines. In like manner, I have often noted lepidopterous species, whose natural food consists of the nectar in summer blossoms, feeding greedily upon fallen fruit. Mr. W. M. Gabb captured the lovely *Morphos* of Nicaragua by baiting with a piece of over-ripe banana;[1] and the Rev. J. G. Wood, a most trustworthy recorder in all that concerns the habits of animals, notices on one occasion having seen whole hordes of the Red Admiral butterfly *(Vanessa atalanta)* darkening the ground where a number of egg-plums lay beneath their parent tree.[2] So, too, amongst birds; while most of them take their sugary food in the form of fruit or seeds, a few kinds, like humming-birds and sun-birds, live largely off the nectar of flowers, mixed with the insects which frequent them.[3] Mr. Webber, an American naturalist, tried the experiment of taming the pretty little ruby-throats, which he fed on syrup alone, and though he found that they could not thrive without a fair proportion of insects as well, he also discovered that they showed a decided partiality for the taste of sugar. "Some which had been thus tamed and set free returned the following year, and at once flew straight to the remembered little cup of sweets."[4] In certain instances, we find the interchange of habit taking place within the limits of a single tribe. Thus, the true parrots live almost entirely off sweet fruits, but their congeners the lories are nectar-eaters. These facts, once more, we may correlate with well-known human habits; as when we see children, whose taste for sweets is derived from frugi-

[1] "Nature," February 7, 1878.

[2] "Insects at Home," p. 401.

[3] On the food of humming-birds, see Wallace, "Tropical Nature," p. 235.

[4] Ibid., p. 137.

vorous ancestors, sucking the juices of honeysuckle and clover, or stealing the honey-bag from our domesticated hive-bees. Indeed, we could have no more significant symbol of the community of nature here pointed out than the fact that we keep these same bees to gather honey for us from the nectaries of flowers.

Conversely, whatever parts of a plant would be injured by the interference of animals, secrete a bitter or acrid juice, which acts deleteriously upon the nerves of taste. Thus, as I have already pointed out, the pericarp, which in fruits-proper is provided with sugary secretions, in nuts is commonly stored with a nauseous principle as a deterrent to animal foes. Again, those fruits which have a sweet pulp generally guard against the loss of their actual seeds by filling them with a bitter substance, of which prussic acid often forms a leading constituent: cases occur in the peach-stone, the apple-pip, and the seeds of oranges or mangoes. That animals as a rule dislike bitter substances is a matter of common observation; and experiments which I have conducted on a small number of insects and birds have always resulted in marks either of indifference or of positive distaste. Thus we see that both in their likes and dislikes a great community of taste runs through all the flower-feeding and fruit-eating animals.

If, now, we turn to the carnivores and carrion-feeders, we shall find a totally different set of sympathies and antipathies. It is true that many dogs and flesh-eating flies love sugar; but they also love numerous other bodies which several of the former class of creatures would never touch. Fresh meat, or still worse, putrid flesh, does not appeal at all to the senses of bees and parrots. Man, of course, forms an intermediate link, a frugivorous animal who has partially adopted carnivorous tastes. Hence we have a certain liking for the flavour of roast beef and turkey; some of us eat high game and caviare; and savages even prefer meat in an advanced stage of decomposition. But these are mere surface-tastes, while the deeper-seated ancestral habits come out strongly in our children and our unsophisticated adults. The liking for strong-tasted meats and half-putrid preparations has to be slowly acquired; whereas the love for sugar, for honey, for fruits, for all sweet things, is born with us into the world, and taken in with our first draught of mother's milk. And in this connection it is worth while to note that the natural food of the human infant contains 62.3 parts of sugar in 1000, while that of a herbivorous calf possesses only 45.6,[1] so that it becomes necessary in giving cow's milk to babies to sweeten it considerably up to the proper point.

Secondly, let us look at the sense of *smell*. Here again we notice that wherever any part of a plant wishes to attract animals, it adds to its sweetness the extra allurement of perfume; and the same perfumes are, as a rule, pleasant to all flower-feeders and fruit-eaters alike. The delicate odour of a peach, a pine-apple, or a strawberry scarcely differs in kind from that of a lily, a hyacinth, or a violet. Mankind, whose tastes in this matter are derived from the tropical fruits, have equal pleasure with bees or butterflies in the dainty scent of clover and meadow-sweet. Only, as might naturally be expected, the perfumes of fruits (which we have already seen reason to believe are comparatively modern structures) are not so highly developed as the perfumes of flowers; whence arises the seeming anomaly that our olfactory nerves are more pleasurably stimulated by the stephanotis or the jasmine, which is relatively remote from our practical life, than by the apple or the pear, which is relatively essential. Of course, the explanation here is that the more powerful stimulant naturally affords the greater volume of pleasure, irrespective of its ulterior usefulness.

In this case, too, we see the essential agreement

[1] Hermann, Human Physiology, English translation, p. 121.

between the higher and the lower forms of vegetal-feeders. For just as our taste for sweets corresponds to the insect's taste for honey, so our love for the perfume of flowers is absolutely identical with the pleasure which draws the butterfly towards the luscious blossoms in our English meadows. And it is worth while to observe that most of the sweet-smelling flowers appear to be quite late developments of vegetal life; a fact which harmonises well with the correspondingly late development of the bees and other highly-adapted honey-suckers. There is no tribe of plants, for example, more noticeable for their perfume than the family of Labiates, which includes the various species of mint, thyme, balm, sage, marjoram, lavender, rosemary, horehound, calamint, patchouli, hyssop, and basil. The flowers of these plants are almost all very peculiarly shaped and highly scented, and their attractiveness for bees has become proverbial—the honey of poetry is commonly "redolent of thyme." Now the Labiates, so far as known, are tertiary plants of rather late date, which did not make their appearance on the earth until bees and other specialised honey-seekers had reached a high point of evolution. Nor should we omit to notice the fact that many of these plants are now cultivated by man for the sake of this very property; lavender to dry and use for scent, patchouli to extract an essence for the handkerchief, and mint, thyme, or sage to flavour various preparations for the table. The exactly similar cases of nutmeg, cloves, and other spices, whose perfume is famous for its diffusibility, while the mode of their dispersion by nutmeg-pigeons has become classical in the pages of Darwin and Wallace, do not need further comment.

In some few instances the pleasure of perfume has been turned into a sexual allurement, as with certain butterflies, where the two sexes exhibit a different arrangement in the nervures of the wings. "In all cases which I know," says Fritz Müller, "this difference in neuration is connected with, and probably caused by, the development in the males of spots of peculiarly formed scales, pencils, or other contrivances, which exhale odours agreeable no doubt to their females. This is the case in the genera *Mechanitis*, *Dircenna*, in some species of *Thecla*, &c."[1] Similar instances occur in the musk-deer and other mammals, whose perfumes are used by human beings as pleasurable stimulants. Indeed, I do not think it would be too much to say that almost every substance which we employ as a native scent is derived either from a vegetal product whose natural function is the attraction of animals, or from an animal product whose natural function is the attraction of the opposite sex.

On the other hand, we find amongst the carnivores and carrion-feeders a totally different form of olfactory pleasure. Dogs, wolves, and other predatory mammals, track their prey by scent, while the smell of raw meat renders the larger cats wild with excitement. Vultures and sopilotes revel in the hideous smell of putrid animal matter, and flies collect around dung or decaying meat. Curiously enough, too, some plants have availed themselves of this special taste, and have laid themselves out, as already noticed, to deceive carrion insects by their likeness in appearance and smell to putrescent flesh. The Sumatran *Rafflesia* and the South African *Hydnora* have large and lurid blossoms, which thus cunningly induce flies to visit them for the purpose of laying their eggs, and are accordingly fertilised by means of an organised deception. To naturally frugivorous man, the scent is, of course, simply disgusting. Yet it is worth notice that many savages, who have acquired for generations the habit of eating half-decomposed meat, positively enjoy those odours which are most distasteful to the nostrils of civilised humanity. As Kolben quaintly phrases it, in his old-fashioned style, "What you take for a stink, a Hottentot, if you

[1] In "Nature," November 29, 1877.

will believe him, receives as the most agreeable perfume."[1]

Hence one may see how futile is the argument of Geiger, who remarks, as illustrating the sensuous inferiority of the lower animals, that it would be useless to offer a dog a bouquet to sniff at.[2] Of course the dog has no reason for being pleased with a perfume which has no special relation to himself or his ancestors in any way; but if we offer him a piece of meat, or set him to hunt down game, we shall find how keenly he has been provided by nature with senses to aid him in his own mode of life. In fact, we can only expect pleasure to be felt where ancestral habit has produced a corresponding sensory system. The transference of feeling whereby we are enabled to enjoy the perfume of flowers does not contradict this general principle, for it is really analogous to the transference whereby the humming-bird sipped the syrup which resembled the native nectar, or whereby we ourselves enjoy sweetmeats and cakes through our hereditary liking for fruits and berries. Honey is a more concentrated form of sugar than that which we get in strawberries or oranges, and frangipanni is a more concentrated form of perfume than that which we get in peaches and pine-apples; but they probably act in just the same way, though to a greater extent, upon the nerves involved as do the original stimulants, and consequently they need no special explanation. Very different, however, would be the case if a dog or any other animal were to feel pleasure in a stimulation derived from some object which had no kind of relation to his ancestral habits. Such an instance, one might venture to say, would be wholly inexplicable, and opposed to all the known principles of scientific psychology.

The sense of *hearing*, though interesting in itself through

[1] Kolben, "Cape of Good Hope," vol. i. p. 231.

[2] "Zur Entwickelungsgeschichte der Menschheit, iii. p. 50.

its connection with song-birds and the sexual allurements of sound amongst sundry insects, has so little relation with our present subject, that I must reluctantly pass it over here.

Lastly, then, we arrive at the sense of *sight*, which we must only examine with special reference to the taste for colour. And here, as before, we note at once that those portions of plants which lay themselves out to attract animals are almost without exception conspicuous for their bright colours. Entomophilous flowers, as we have already abundantly observed, have a monopoly of brilliant corollas, while fruits-proper differ from nuts in the startling vividness of their hues. These facts would go by themselves to prove that flower-feeding and fruit-eating animals find an allurement in colour. It is certainly a noticeable fact that just as the sweetness of fruits answers to the sweetness of honey, and just as the scent of fruits answers to the scent of flowers, so do the colours of fruits answer exactly to the colours of flowers. It would seem as though, in every case, nature found a single mode of modifying the nervous substance was amply sufficient (because simplest and easiest) alike for insect and reptile, for bird and ape and human being.

Some special facts help to point in the same direction. Thus we find within the limits of a single family, the Rosaceæ, a large number of fruits-proper, the plum, the apple, the hip, the haw, the strawberry, the raspberry, and the bramble, in which the pericarp or other succulent portion, besides being sweet and scented, is more or less brilliantly coloured; and again, we also find an aberrant member, the almond, whose seed is enclosed in a nut, and whose pericarp accordingly is hard, dry, and green or brownish, after the usual fashion of nuts. Or once more, we know that in most Oceanic islands there are few flying insects, and that most of the flowers are destitute of bright corollas; but Mr. Wallace has pointed out that in a few, cases, where honey-sucking birds frequent such islands the flowers are extremely large and handsome.[1] This fact clearly shows that the birds in question find colour quite as attractive as do bees or butterflies.

I do not propose to enter very fully into this question until we have seen what light may be cast upon it by the examples collected and the inferences drawn in the succeeding chapter. But I should like to point out here that if our general theory of pleasure be well-founded, it must necessarily result that flower-feeding and fruit-eating animals should derive agreeable sensations from coloured objects. So soon as the eyes of insects or birds have become sufficiently differentiated to discriminate the pinkish or ruddy flower-cases and fruit-vessels from the green leaves around them, and to employ their nascent sense in the quest for food, so soon must the special nerves exercised and strengthened in this process receive some faint pleasure from their due stimulation. And the more developed the nerves become, the more intense must be the resulting enjoyment, till at last an ever-increasing gratification would grow up side by side with the growth of entomophilous blossoms and coloured fruit, becoming stronger and stronger day by day as the structures increased by practice in calibre and power.

Two short passages from the works of two leading evolutionists will serve to bring out in strong relief the position here assumed. Mr. A. R. Wallace thus sums up his view with regard to the nature of colour-perception in the lower animals:—"The fact that the higher vertebrates, and even some insects, distinguish what are to us diversities of colour, by no means proves that their *sensations* of colour bear any resemblance whatever to ours. An insect's capacity to distinguish red from blue or yellow may be (and probably is) due to perceptions of a totally distinct nature, and quite unaccompanied by any of that sense of enjoyment or even of radical distinctness which pure colours excite in us. Mammalia and birds,

[1] Tropical Nature, p. 238.

whose structure and emotions are so similar to our own, do probably receive somewhat similar impressions of colour; but we have no evidence to show that they experience pleasurable emotions from colour itself, when not associated with the satisfaction of their wants or the gratification of their passions."[1] From the whole of this passage, with all due deference to Mr. Wallace (for most of whose work I entertain the deepest respect), I must take leave to differ *toto cœlo*. Each of its three sentences appears to me to contain a fallacious position. For the first, the burden of proof lies distinctly with Mr. Wallace, not with his opponents; because, where the external stimulus is the same, and where a general continuity of structure exists, we are not justified in assuming a difference of sensation without some special reason; nor do I believe that so clear a thinker as the author of the "Malay Archipelago" would have assumed such a difference, were it not for that predisposition to find some effective distinction between man and the lower animals which has so often led him into questionable conclusions. For the second, it seems to me that, since the insect's need for discriminating colour is far greater than our own, analogy would lead us to suppose that his enjoyment would be even deeper, and his sense of distinctness more marked, than in the human subject. For the third, the single instance of the oft-quoted bower-birds, who collect coloured objects to decorate their meeting places, shows that some vertebrates at least possess a liking for brilliant hues in themselves, of a truly æsthetic sort: and the behaviour of monkeys with regard to flowers and birds, or to red shawls and other strikingly-dyed articles, would seem to point in the same direction. For the rest, Mr. Darwin has gathered together a few isolated instances of disinterested love for colour in a well-known section of his "Descent of Man."[2] It is true that the evidence on this head is still far from satisfactory; but it must be

[1] Tropical Nature, p. 243.

[2] Vol. ii. p. 110.

remembered that without the assistance of language definite information as to tastes cannot be procured except with great difficulty, and that human infants only display the love for colour in the same simple ways as monkeys or bower-birds.

The second passage to which I would refer is one from our great naturalist himself. "How the sense of beauty in its simplest form," says Mr. Darwin,—"that is, the reception of a peculiar kind of pleasure from certain colours, forms, and sounds,—was first developed in the mind of man and of the lower animals, is a very obscure subject. The same sort of difficulty is presented if we inquire how it is that certain flavours and odours give pleasure, and others displeasure. Habit in all these cases appears to have come to a certain extent into play; but there must be some fundamental cause in the constitution of the nervous system in each species."[1] Now this fundamental cause I believe to reside in the general law that pleasure accompanies normal stimulation when not excessive in amount; while the influence of ancestral habit, joined with natural selection, has so modified the nervous system in each case that it finds itself normally stimulated by those external agents which conduce to the general welfare of the organism, and excessively or destructively stimulated by those which conduce to its general detriment.[2] Accordingly, I infer that in all fruit-eating and flower-feeding species, a taste for sweet flavours, delicate perfumes, and bright colours will have been slowly developed by the hereditary mode of life; and that the taste so developed will have opportunities for exerting itself in the sexual selection of bright-coloured mates.

If this be so, then it must follow that flower-feeding and fruit-eating insects or vertebrates will be specially distinguished from other animals by the exceptional brilliancy of their colouration. In the next chapter we will

[1] Origin of Species, 6th edit., p. 162.

[2] See my "Physiological Æsthetics," *passim*, where this main principle is worked out in detail.

submit our general conclusion to the test thus suggested to us, and if we find that bright hues are, as a matter of fact, unusually common amongst those species in which we have inferred *a priori* that a taste for brilliancy would have been evolved by the circumstances of their life, then we shall have added another item to our cumulative proof of the existence and influence of a colour-sense among the lower animals. Just as we saw that the taste for sweets, formed upon flowers and fruits, could be transferred to syrup, sugar, honey, bonbons, cakes, and puddings; just as we saw that the human liking for dainty perfumes, formed upon strawberries and oranges, could be transferred to hyacinths and heliotropes: so, I believe, the love for colour, formed upon the natural food of the various species, can be transferred to the choice of beautiful mates, and, strengthened by this transference, can be handed down by heredity to mankind till it results at last in the disinterested delight in the sunset and the autumn hues, in the flowers of our gardens, the varying tints of our landscapes, and the exquisite harmony of our Guidos and our Rossettis. Let us see, then, how far the facts of nature will bear out the theory on this subject which we have framed from the analogy of our other senses.

CHAPTER IX.

THE DIRECT REACTION OF THE COLOUR-SENSE UPON THE ANIMAL INTEGUMENTS.

IF any unscientific person were asked to name the two most beautiful classes of animals in the world, he would unhesitatingly answer, "Butterflies and humming-birds." It is a significant fact that these are perhaps the most exclusively flower-haunting of all invertebrate or vertebrate creatures respectively. And if he were asked to name any other birds, besides the single family above mentioned, which are specially conspicuous for their brilliant colouration, he would probably reply, "Parrots and their allies." It is an equally significant fact that these birds are fruit-eaters. Following up the hint thus given us, we may run through the chief instances of brilliant species in both great divisions of articulates and vertebrates, in order to discover whether there is any constancy of connection between the nature of the food and the colouration.

As before, we may narrow down our consideration of the articulates to the great group of insects, because we know too little about the habits of their marine congeners to argue with any certainty as to their traits; while the other land-articulates are relatively unimportant for our present purpose. Now amongst the insects, the most brilliant order are the Lepidoptera, including both the butterflies and moths, which, it need hardly be said, feed upon flowers. Of course, it may be readily objected that the amount of food eaten by the perfect winged insects is relatively small, and that the caterpillars live for the most part upon the green portions of plants. Indeed, some butterflies possess no mouths at all, and pass the whole of their short lives by the expenditure of energy laid up in the larval condition. Yet this objection does not really invalidate the general conclusion; for the eyes of the perfect insects have been evidently adapted to the colours of flowers, and the main object of their winged state is the perpetuation of the species; so that we can easily understand how the tastes ancestrally formed in their last stage should dominate the selection of their mates. Hence we find that the colours of caterpillars are mostly protective, being due to natural selection alone, while those of butterflies are mostly attractive, being largely due to sexual selection.

Furthermore, if we examine the Lepidoptera in detail, we shall find similar conclusions thrust upon us. They may be divided into two great sections,—the moths and the butterflies,—of which the former are mainly nocturnal or crepuscular, while the latter are mainly diurnal. Now there can be no comparison as to brilliancy between the vast majority of these two groups. The moths vary for the most part from dingy grey to dusky black, while the butterflies revel in every shade of golden yellow, splendid crimson, and metallic blue. Again, the eyes of these two divisions differ in structure in a manner which suggests the inference that the diurnal insects are much better provided with optical discrimination than their nocturnal allies,[1] especially when the facts are compared with certain exactly similar or corresponding peculiarities in the nerve-terminals in the eyes of owls and bats.[2]

Nor does the argument stop here. Certain species or families of moths fly by day, and these (*e.g.*, the crimson-speckled *Deiopeia pulchella*, *Callimorpha dominula*, the *Agaristidæ*, *Ægeriidæ*, *Zygænidæ*, &c.) are as brightly tinted as any butterflies. Mr. Bates mentions a Brazilian *Urania*,

[1] See a paper by Mr. B. T. Lowne, F.L.S., in Proc. Roy. Soc., No. clxxxvi. p. 261, 1878.

[2] See below.

"a beautiful tailed and gilded moth, whose habits are those of a butterfly;"[1] and I know by personal experience the Jamaican species of similar tastes, whose wings are exquisitely dappled with black, green, and gold. Indeed, it may be stated generally that most brilliant insects are fond of displaying themselves in the open sunlight; while conversely most insects which frequent dark places or fly by night alone are dusky and ugly. By the side of these facts it is well to remember that diurnal flowers, which appeal to bees and butterflies, have corollas in every variety of red, blue, orange, and purple; while nocturnal flowers, which appeal to moths, are generally white or pale yellow in hue.

If we compare the carrion-feeding and omnivorous flies with the flower-haunting Lepidoptera, we see at once the difference of taste, as exhibited in the presence or absence of sexual selection. The flies are generally dark and inconspicuous, with thin transparent wings; and whatever beauty they possess is due to mere surface-play of interference-colours, not to the existence of distinct pigments. Nothing in the nature or appearance of their ordinary food-stuffs would lead us to credit them with any ancestral love for pure and beautiful hues.

There are, however, some striking exceptions amongst the dipterous insects, which fully bear out our general conclusion. The tribe of *Brachystomatidæ* are "large flies, adorned with brilliant colours, which for the most part haunt flowers, living upon honey."[2] The Notacanthæ "are also frequently brilliantly coloured. They generally frequent flowers." The Conopidæ, too, "are elegantly variegated in their colours. They may be found in great abundance during the summer, hovering upon their powerful wings over flowers in gardens and elsewhere." The invariability of this conjunction will hardly allow us to regard it as accidental.

[1] The Naturalist on the Amazons, p. 105.

[2] Dallas, The Animal Kingdom, p. 191.

Beetles or Coleoptera show us like results. The carrion-feeders are for the most part black and unattractive, as are also the nocturnal species and those which live in water. But the brilliant species are often flower-feeders, and fly much in the sunlight, exhibiting their exquisite metallic sheen, and displaying their beauty to their mates. If we take the Lamellicorn beetles in particular, we shall find a very instructive difference between two of their closely-allied families. The cockchafers feed on leaves, and they are some of the dingiest creatures of their class; but the *Cetoniadæ* feed upon flowers, as their English name of "rose-beetles" implies, and they are conspicuous for the beauty of their colouring, including "a vast number of the most brilliant exotic species." It is a significant fact, too, that their mandibles have been specially modified, so as to enable them to lick up honey, which clearly shows a long persistence in flower-haunting habits, quite sufficient to account for the formation of a definite taste for colour. "Those species," says Latreille, speaking of Lamellicorns generally, "which live in the perfect state upon vegetable substances, are remarkable for the brilliancy of the metallic colours with which they are adorned. But the majority of the other species, which subsist on decomposing vegetation, manure, tan, or excrementitious matter, are generally of a uniform black or brown hue." The magnificent Buprestidæ are also, in many cases at least, flower-haunters. The tetramerous beetles, including the gorgeous Longicorns, may be regarded as mainly flower-feeding or plant-haunting insects, and their colours, as a rule, are very brilliant. Similarly, among heteromerous beetles, the Trachelia of Professor Westwood are active diurnal animals, most of which live upon the leaves or suck the honey of flowers, and they are often adorned with beautiful colours; but the Atrachelia, nocturnal in their habits and foul feeders, are generally black and dingy in hue. Altogether, though it would be difficult to sum up so very varied a group as the Coleoptera in a single sentence, I think a careful examination will convince the inquirer that here, too, a general connection exists between brilliancy of hue and flower-feeding or fruit-eating habits.

When we turn to the Hymenoptera, or bee and wasp tribe, a great difficulty at first sight arises in our way. It would seem as though some of these insects ought to be of all others the most gorgeously arrayed, and yet for the most part they are but plain and inconspicuous creatures. However, a closer view dispels the doubt. Only one tribe of the Hymenoptera, that of the Anthophila, or bees, is specially adapted for feeding on flowers. Now these fall into two classes, the social and the solitary; and the habits of the former class, of course, place them almost entirely outside the sphere of sexual selection. The queen or mother-bee, a prisoner for life, does not herself seek honey among flowers, and those bees which do so have no power of transmitting their tastes or habits to descendants. Indeed, the whole question of heredity in these interesting animals remains involved in so much mystery, that it would be useless to base any arguments upon it in either direction.

On the other hand, the solitary bees are often beautifully coloured, as in the well-known case of the carpenter-bee. The Nomadæ, or cuckoo-bees, are also very brilliant insects. The omnivorous wasps do not exhibit equal beauty; and the almost wingless, highly social, and mainly carnivorous ants are quite inconspicuous animals, probably possessing colour-perception in a very sight degree. But the Chrysidæ, a family of lower Hymenoptera, are also solitary flower-haunters, and "in the richness of their colours they vie with humming-birds."

Of course, it cannot be denied that a few less notable classes of insects which do not haunt flowers are nevertheless more or less brilliant in their colouring. But this does not interfere with the general truth of our inference that flower-feeders are specially noticeable for their bright hues. If we can find ground for believing that those species which habitually seek their food in gay blossoms have developed a peculiar love for colour, which is shown in their choice of mates, we shall have done quite as much as is needful. Besides, other sources exist from which a love for colour may be derived as well as from flowers. For example, the Orthopterous family of Mantidæ, or praying-insects, are noticeable in many instances for their bright tints; but as they live by devouring other insects, a taste of the sort may have been generated indirectly in their case from the nature of their food. Still, most of the Mantidæ seem rather to be deceptively coloured like their surroundings, so as to escape the notice both of their prey and of their enemies among birds. A similar explanation must be given in the case of the Phasmidæ, or leaf and stick insects, whose colouring, though sometimes comparatively striking when seen in a cabinet, is purely imitative of the foliage or fallen sticks around them. Many flower-haunting spiders, too (to travel for a moment outside the limits of the true insects), are "exquisite gems" of ruby or sapphire colouration; yet we must rather attribute their magnificent hues to the need for imitating the petals on which they creep than to sexual selection. Such instances, however, in no way militate against our main conclusion; they only show that other causes at work have sometimes produced similar results to those which we are contemplating, though in a different manner. Thus it is quite possible that the beauty of the tiger-beetles may be due to their habit of hunting other bright-coloured insects in the open sunlight.

There still remains a margin of inexplicable cases, as might naturally be expected, for the study of these questions is yet in its infancy, and only a few isolated endeavours have hitherto been made to account at all for the external appearance of animals. Among such may be mentioned the gorgeous tropical locusts, the dragon-flies (which, however, prey upon many brilliant species), and several of the Longicorn beetles. But all these instances cannot blind us to the fact that if we look at the flower-haunting insects in the mass they are by far the most conspicuous for beauty of their kind. It is not necessary to explain in detail the colouring of every individual species—an endless task, which would demand far more competent treatment than I could give: it is quite sufficient if we find a general coincidence between bright food and bright hues in the feeder, without pretending at once to account for every apparent exception.

And now, before we pass on to examine the vertebrate world in the same manner as we have here examined the articulate, we must pause a moment to meet, or rather to touch lightly, a powerful objection which has been urged against the whole theory of sexual selection by no less a writer than Mr. A. R. Wallace. In his work on "Tropical Nature," that ingenious evolutionist endeavours entirely to overthrow Mr. Darwin's laborious superstructure, raised with so much toil and skill in the "Descent of Man," and to substitute for the doctrine of voluntary choice, which the older naturalist there advanced, a number of minor principles, whose joint action may be supposed to have produced the existing colours of the animal world. Mr. Wallace has urged his objections with even more than his usual ingenuity; and I may frankly confess that he has attacked the theory of sexual selection with such judicious vigour that I felt inclined on first reading his essays to abandon entirely all that part of the present work which was based on the original doctrine enunciated by Mr. Darwin. On fuller consideration, however, I have determined, though with much hesitation, to retain it, in hopes that the few suggestions which I have to make upon the question may possibly contribute to a clearer comprehension of its issues, and to its ultimate settlement in one direction or the other. I cannot for a moment pretend to meet a distinguished specialist like

Mr. Wallace on his own ground; nor do I wish to dispute the force and accuracy of many among his criticisms; yet I trust I may be able to add my small quotum of facts and inferences to the whole data for a final opinion, and I believe that the very generalisation which it is the object of the present chapter roughly to establish, may be useful in showing some additional basis for the theory of sexual selection. For if we find that fruit-eating and flower-feeding animals do really exhibit unusually beautiful colours, then we shall have some further ground for believing that they do exert some vague sort of choice or preference in the search for mates.

Accordingly, I shall jot down in passing, under each head, such points as occur in relation to this vexed question.

In the first place, it is well to remember that sexual selection does not necessarily imply a deliberate exercise of will, or comparison between the rival charms of various possible mates, which seems hardly probable in the case of insects at least. We must guard against the error of transferring our own highly-developed notions of beauty to the simple half-conscious minds of beetles or butterflies. With us, beauty is a very complex idea, compounded of numerous presentative, representative, and re-representative elements; and our choice of mates is a conscious selection, guided more or less deliberately by many complicated considerations, often too numerous for analysis even in our own minds. But, without attributing to the butterfly any such highly-evolved feelings, we may well believe that certain individuals, whose brilliant colours contrasted strikingly with the green foliage about them, might more readily succeed in attracting the attention of mates than their dingier compeers. We know that the eyes of insects are allured by the colours of flowers, which have been developed for this very purpose: and there is therefore nothing improbable in the supposition that they are also allured by bright hues in their fellows. In short, I am inclined to suggest that *conspicuousness* rather than *beauty* in our human sense is aimed at by the butterfly's wing. To some this will doubtless appear equivalent to a surrender of the whole position; but a little reflection will probably remove such an apprehension. For the sense of beauty in its simplest form, as Mr. Darwin rightly puts it, is nothing more than "the reception of a peculiar kind of pleasure from certain colours, forms, and sounds."[1] Now we have seen reason to believe that the insect feels some slight pleasure in the perception of colour in flowers; and we may also conclude that the pleasure is equally felt from the similar stimulation of a brilliant mate. In either case, it seems probable that a semi-automatic action is set up by the sight of the bright hue, which leads on the insect instinctively to the blossom or the opposite sex alike. Such a selective process does not seem to me at all to transcend the narrow faculties of a beetle or a butterfly. Mates on this theory are not chosen *on account* of their brilliancy, but their brilliancy renders them the most natural objects to choose.

The familiar instance of the moth and the candle shows us this automatic tendency in its fullest form. In that case it would seem as though the intensity of the visual stimulus set up a motor activity of the wings, which would become more and more powerful the more directly the eyes of the insect were turned towards the light. Accordingly, any random movements in that direction would be followed by more and more rapid gyrations, ending, as we know, in the central flame, whenever the eyes both pointed straight toward that quarter. We must conclude here that in the natural circumstances of moths few bright objects would occur around them, except flowers, and so the eye has probably been connected with the motor system in such a manner that the reception of a light-stimulus acts immediately upon the wings. In the presence of such a rare and unpremeditated object as a candle, the hereditary

[1] Origin of Species, sixth edition, p. 162.

instinct or organised habit becomes a bad guide, finds itself at fault, and finally results in the insect's death. But the case is very much like that of a human child, who knowing that bright red berries are usually sweet and innocuous, poisons itself with those of the cuckoo-pint or the yam. The instinctive pleasure can only have been adapted to the usual environment of the race, not to special and exceptional circumstances like artificial lights and poisonous berries.

It is possible that the light of fire-flies and glow-worms may be similarly of use for the guidance of the sexes, though Mr. Belt believes it to be a warning mark of inedibility. However this may be, it is certain that butterflies and insects generally are so constituted that they can distinguish their own mates unerringly from all others, even though the difference between the species be almost microscopical. Whether this discrimination be due to sight, or, as some authors maintain, to smell, it shows equally that a minute correspondence exists between the senses of the insect and its habits of life. And as this correspondence, so far as each separate species is concerned, must have had a beginning at some time or other, and consequently a cause, there seems no sufficient ground for doubting that conspicuousness of colour formed one of the determining conditions. Indeed, I cannot myself see why Mr. Wallace, who allows the attractive nature of colouring in flowers, should deny its attractive nature in the question of sex.

It is allowed on all hands, I believe, that the special odours of insects,[1] as well as their stridulating noises,[2] are guides to the sexes in their search for one another. It does not appear that colour stands on any different footing in this respect.

Furthermore, many insects have two sets of colours, apparently for different purposes, the one set protective

[1] See F. Müller in "Nature," November 29, 1877.
[2] Darwin, Descent of Man, *passim.*

from the attacks of enemies, the other set attractive for the opposite sex. Thus several butterflies have the lower sides of their wings protectively coloured, so as to preserve them from the notice of birds or lizards, while they sit with folded wings on a flower or leaf; whereas the upper sides are attractively coloured, and displayed in the open sunlight as they flit about in search of mates. Moths, again, whose habits of folding the wings are exactly opposite, often have their upper surfaces imitative or protective, while the under sides are bright and beautiful. Sometimes the union of protective and attractive features in the same insect is very striking. Thus Mr. Wallace himself mentions a leaflike butterfly, *Kallima paralekta*, whose wings are purple and orange above, but exactly mimic dead foliage when closed;[1] this insect always rests among dead or dry leaves, and imitates every stage of decay, being even apparently spotted with small fungi. So, too, Mr. Bates tells us of a grasshopper, *Pterochroza*, whose sheath-like fore-wings similarly resemble a green leaf, while its hind-wings, usually covered except during flight, are "decorated with gaily-coloured eyelike spots."[2] Again, Mr. Belt observes that the males of some butterflies which mimic the Heliconidae are coloured with black and white, quite unlike the mimicking females,[3] while some South African species show perfectly marvellous differences in this respect. In all these cases, one cannot but believe that while the one form of colouring has been acquired for the sake of protection, the other must differ from it for some sufficient functional purpose.

Once more, there seems to be a pretty constant connection between the general beauty of the flora in any particular district and the general beauty of its insect

[1] Malay Archipelago, p. 131.

[2] The Naturalist on the Amazons, p. 145.

[3] Mr. Wallace seems to me to have quite perverted the simple explanation of this fact by neglecting the obvious truth that white and pale yellow are really very brilliant colours when compared with the green or brown of ordinary life. See "Tropical Nature," p. 204.

inhabitants. Of course, it has long been noted that where few or no flying insects exist, few or no bright-coloured flowers are found. But what I wish to point out here is the converse fact that where bright blossoms are common, insects are brilliant, while where most blossoms are inconspicuous, most insects are dingy. On this head the mass of evidence, though difficult to quote, is overwhelming. A few of the more striking instances may, however, be briefly given here. On the whole, the brightest flowers grow among the tropics, and on the whole, tropical insects are unusually beautiful. The flora and the minor fauna of Madagascar are equally remarkable for their splendid hues. Sir Joseph Hooker notices the extreme magnificence of the Himalayan flora; and he also mentions the singular loveliness of the butterflies.[1] Sir Emerson Tennant speaks continually of the beauty of the "brilliant flowering shrubs" in Ceylon,[2] and he likewise speaks of the beauty of its butterflies in large numbers.[3] In Mr. Bates's work on Brazil, I notice almost on every page the conjunction of pretty insects with striking flowers, or the absence of both together.[4] Especially does he note the beauty of the Longicorn beetles found on flowers[5] at Caripi, while a few pages before he remarks upon the abundance of exquisite blossoms at the same place.[6] I cannot help interpolating here, though out of proper order, the remark that, just in like manner, he seldom mentions the capture of a handsome bird without adding that it was shot in a fruit-tree. Almost the only bright butterfly which I ever observed in large numbers in Jamaica was the *Callidryas eubule*, feeding on the abundant yellow cactus blossom, whose hue it exactly resembled, and which is the only common and conspicuous large entomophilous flower in the colony. Both Mr. Wallace himself

[1] Himalayan Journal, i. 152, and ii. 98.

[2] Ceylon, pp. 87, 88, 92.

[3] Ibid, pp. 247, 248.

[4] See the Naturalist on the Amazons, pp. 20, 274,

[5] Ibid, p. 110.

[6] Ibid, p. 101.

and Lord George Campbell,[1] an excellent non-scientific observer, remark upon the beauty of the insects and flowers of the Ké Islands. Similarly, the flowers of Amboyna are paralleled by its gorgeous beetles, butterflies, and birds.[2] On the other hand, in New Zealand "there are scarcely any gay flowers and blossoms; but few herbaceous plants, nothing but shrubs and trees; shrubs with obscure green flowers;"[3] while at the same time "the butterflies are distinguished neither by size nor by richness of colour."[4] Oceanic islands, which have few or no bright flowers, are remarkable for the absence of bright insects; and Mr. Darwin mentions of the Galapagos group both the fact that he "did not see one beautiful flower," and also the universal dinginess of the whole fauna. But this question is one on which it is difficult to quote positive authorities: it must rather suffice to mention that a considerable search into the general impressions of travellers—the best evidence, after all, on so indefinite a point—has convinced me that such a general relation does actually obtain. It is no answer to say that the insects are necessary for the production of the flowers: the real point at issue is this—why are insects bright where bright flowers exist in numbers, and dull where flowers are rare or inconspicuous? We can hardly explain this wide coincidence otherwise than by supposing that a taste for colour is produced through the constant search for food among entomophilous blossoms, and that this taste has reacted upon its possessors through the action of unconscious sexual selection.

Finally, it would seem that Mr. Wallace's own theory of "typical colours" really allows all that is here required. For Mr. Wallace speaks distinctly of the "need of recognition and identification by others of the same species"[5]

[1] Log-Letters from the *Challenger*, p. 187.

133. See also Sir Joseph Hooker's "Flora of New Zealand," p. 28.

[4] Hochstetter, p. 170.

...nical Nature, p. 215.

as one among the determining causes of such colours, not only in the case of birds, but also in that of butterflies, four families of which he specifies by name. Now, conspicuousness of hue is certainly a very simple means of identification: and I think we must allow that it acts as an allurement to the eye in the case of flower-feeding species. I am quite disposed to accept Mr. Wallace's belief that the actual disposition of the stripes, spots, and lines, is a matter of special typical arrangement; but even here one would naturally suppose that some minute cause must at first have led to the preference for one arrangement over another. Briefly, to sum up the whole question, after making full allowance for warning colours and for mimetic or other protective colours, there seems to remain a large margin of cases in which brilliancy exists for purely attractive purposes: while often the attractive function is combined with more or less of protective device. Anybody who watches our own English butterflies on a sunny day can hardly doubt that display forms a part of the object for which their yellow, orange, or crimson-spotted wings have been developed, and that such display makes them an easier mark for their scattered mates. Above all, it is necessary to remember that the winged condition in these insects is hardly more itself than a sexual device for the perpetuation of the various species.

And now let us pass on to consider the fuller evidence afforded us by vertebrates.

To begin with fishes, it must be allowed that our present knowledge of their habits scarcely justifies us in making any distinct inferences from their colouring. Nevertheless, a few facts may perhaps be gleaned even here. The mass of lower marine animals are brilliantly coloured with what seem to be purely adventitious or protective colours; and we had occasion already to remark upon the similarity between their hues and those of fungi, saprophytes, and other like vegetal organisms. As a few examples may be mentioned sea-anemones, star-fish, echini, medusæ, ascidians, sea-slugs, and corals. When we reach the mollusca, the colouring begins to assume a different type, but it would be difficult to assign any sufficient cause for its occurrence. Amongst the marine articulata, and especially the crustaceans, many species exhibit a regularity of hue, and minute arrangement of spots and lines, which seems to bespeak a certain amount of sexual selection. These doubtful instances, however, we must pass over, not because they are less interesting, but because they are so very uncertain; and in a brief examination like the present, we must necessarily confine our attention to the most salient points. Now, the abundance of coloured organisms, both animal and vegetal, in the sea, affords a fair ground for belief that fishes may have acquired a colour-sense, and a taste for bright hues. We know that they (as well as the crustaceans) can be attracted by crimson or scarlet rags, and that glistening objects like metals or artificial baits rapidly seize upon their attention. As to the brilliancy, beauty, and regularity of their colouring, the reader must be referred to Mr. Darwin's description in the "Descent of Man," where he will find a full account of the principal facts which go to prove the existence among them of sexual selection. I must content myself here by saying that for gorgeous colouring and variety of patterns they are nowhere surpassed in the whole animal kingdom; and that metallic sheen is especially conspicuous among the devices whereby they insure the attention of their mates.

As regards the special question upon which we are now engaged, a few facts may be shortly set down. In the first place, the lower animals of tropical seas are on the whole much more brilliantly coloured than those of temperate climates, and the same remark holds good of the fishes. Mr. Darwin has noticed the extreme beauty of the shoals which played in and out among the brilliant organisms of the coral lagoons; and though Mr. Wallace objects that this may be due to protective causes, in order that they may escape notice among the bright creatures about them, yet as Mr. Darwin pertinently replies, he was struck by the obvious conspicuousness of their appearance rather than by their resemblance to environing objects. I have myself observed the same point frequently in the West Indian harbours, where the fish and the neighbouring creatures, seen through clear still water, all appeared equally beautiful and noticeable. But I cannot do better than quote Mr. Wallace's own description of the harbour of Amboyna. "The bottom," he says, "was absolutely hidden by a continuous series of corals, sponges, actiniæ, and other marine productions of magnificent dimensions, varied forms, and brilliant colours. . . . In and out among them moved numbers of blue and red and yellow fishes, spotted and banded and striped in the most striking manner, while great orange or rosy transparent medusæ floated along near the surface."[1] And elsewhere he observes, "The fishes (of Amboyna) are perhaps unrivalled for variety and beauty by those of any one spot on the earth." These facts at least tend to show that our theory does not receive any active contradiction from the conditions of marine existence; and they are confirmed by numerous other like passages in several authors whom I think it superfluous to quote.

On the other hand, the larger predatory species, such as sharks and pikes, together with the majority of temperate fishes, are decidedly wanting in brilliant hues. Mr. Wallace observes that river fish, even of the tropics, rarely if ever have gay or conspicuous markings;[2] and this is just what we would expect from the nature of their food, consisting as it does of worms, small flies, and other inconspicuous objects. However, we must allow that in this case Mr. Wallace has witnessed against himself with excessive fervour; for many river fish undoubtedly *have* very

[1] Malay Archipelago, p. 295.
[2] Contributions to the Theory of Natural Selection, p. 55.

brilliant colours, as I can especially testify from having caught in my youth numbers of the Canadian sun-fish, perhaps the most exquisite creature of its class which I have ever seen. But this particular species lives in shallow marshy water, and *may* have derived its tastes from butterflies and dragon-flies. Professor Agassiz speaks much, too, concerning the beauty of the Amazonian fishes,[1] which he describes as having a quasi-marine character;[2] and in spite of a possible accusation for grotesqueness, I would venture to suggest that their colouring may *perhaps* be due to those numerous butterflies which Mr. Bates so often describes as flitting in numbers along the banks of that mighty river. However this may be, we must leave these somewhat inconclusive cases, and hurry on to the terrestrial vertebrates.

The amphibia yield little evidence in either direction. The beautiful colouring of tree-frogs, when compared with toads and common frogs, is more probably protective than attractive. Still, the newts show us very unmistakable signs of sexual selection in their crests; and we cannot say that the habits of amphibia may not have generated a love for colour.

Among the reptiles, however, a good many facts may be quoted to our purpose. In the first place, the large water-haunting crocodiles and alligators are peculiarly dull and unsightly objects; while the whole order of Chelonia, including the turtles and tortoises, are as inconspicuous for colour as they well can be. On the other hand, the smaller saurians, many of which lead an arboreal life, and feed off varied food, sometimes fruit, sometimes insects and other small animals, are often noticeable for their beauty. Most iguanas, great jungle lizards, contrast strongly in hue with the crocodiles; but one species, *Amblyrhynchus cristatus,* which inhabits the dull-coloured Galapagos Islands, and has taken to a strangely abnormal marine life, is remarkable for the same sombre tints

[1] A Journey in Brazil, p. 184. [2] Ibid., p. 238.

which characterise the other animals of that singular archipelago, being described by Mr. Darwin as of "a dirty black colour." The lesser lizards give unmistakable proofs of sexual selection in the brilliant pouches which they protrude when sunning themselves, and whose exquisite colours have struck every observer. Their mechanism for changing the hue of their skin, by compressing or spreading the layers of pigment cells, has already been noticed; and it seems to betray a considerable sensitiveness to colour. Dr. Günther also sees reason to believe that the frugivorous lizards have the tongue as an organ of taste, while in the insectivorous species he considers it merely an organ for the prehension of prey.[1] Now, a large number of all lizards are noticeable for their exquisite hues. Green, as might naturally be supposed, from protective reasons, forms the general groundwork of their colouring; but, as often happens under similar circumstances, many other shades are intermingled, apparently to perform the attractive function. Especially is this noticeable in the *Anolis* and other like genera, whose beautiful orange pouches consist of folds of the skin, which are concealed under ordinary circumstances, but protruded for display when the animal feels himself secure, and can sun himself at leisure on a dead branch. The family of *Agamidæ* include many of the most brilliant species, especially the exquisite *Draco*, whose beauty Mr. Darwin extols so highly;[2] and these, says Dr. Günther, are arboreal in their mode of life, while the dull-coloured genera inhabit rocks or plains.[3] It is true that *Draco* feeds on insects; but when we remember the beauty of many among these little tropical creatures, we see fair grounds for believing that its habits may have led it to form a taste for colour. The Geckos also eat moths;[4]

[1] Reptiles of British India, p. 56.

[2] I shall note hereafter the singular coincidence between the possession of a flying apparatus and general brilliancy of hue, which seems to obtain amongst butterflies, birds, these lizards, and even the flying squirrels, &c.

[3] Reptiles of British India, p. 120.

[4] Günther, p. 100.

while Mr. Gosse found on dissection many pretty insects in the stomach of the lovely Venus lizard of the West Indies.[1] Here, too, we may even see the indirect effect of flowers and fruits; for Mr. Wallace, after noticing the "abundance and varied colours of the little jumping spiders which abound on flowers and foliage (in the Aru Islands), and are often perfect gems of beauty,"[2] goes on to say about the lizards in the same place, "Every rotten trunk or dead branch served as a station for some of these active little insect-hunters, who, I fear, to satisfy their gross appetites, destroy many gems of the insect world, which would feast the eyes and delight the heart of our more discriminating entomologists."[3]

Among snakes we find somewhat similar facts. While the arboreal species, still having green for their groundwork, "are characterised by their vivid colouration,"[4] the ground-snakes, burrowing-snakes, and water-snakes are mostly dull and inconspicuous. Of the ground-colubrides, in particular, Dr. Günther says, "They live on the ground, and are generally of not brilliant colouration; only a few, which frequent grassy plains, are of a bright green colour."[5] The Dendrophidæ eat lizards and like prey, and are usually very bright; their colours sometimes, as in the magnificent *Chrysopelea ornata*, being decidedly not protective. Of course, almost all arboreal snakes feed upon various foods, such as birds, smaller reptiles, or other brilliant animals, whose colours may have served to give them a taste in that direction. I confess I attach little importance to any of these cases; still I think it worth while prominently to call attention to the fact that most arboreal creatures are conspicuous for their exceptional brilliancy.

Doubtless much of the bright colouration in all these animals is more or less warning or protective. Thus, one

[1] The Naturalist in Jamaica, p. 145.
[2] Malay Archipelago, p. 432.
[3] Ibid., p. 433.
[4] Günther, p. 166.
[5] Ibid., p. 221.

may mention Mr. Belt's "little frog that hops about in the daytime, dressed in a bright livery of red and blue."[1] Mr. Belt suspected this species to be inedible, from the staring nature of its hues; accordingly, he offered one to some ducks, but only succeeded in making one young duck bite it amongst some meat; and the bird "instantly threw it out of its mouth, and went about jerking its head as if trying to throw off some unpleasant taste." Then, again, there are the coral-snakes of South America, for which Mr. Darwin has fully accounted. Once more Mr. Wallace, in his "Contributions to the Theory of Natural Selection," has pointed out that green lizards frequent trees, while many Geckos are so marbled as to resemble the bark on which they crawl.[2] Mr. Belt speaks also of a green Nicaraguan species, which looks exactly like the herbage among which it lurks, and has actually acquired leaf-like expansions to deceive its prey.[3] Mr. Bates, too, notices a pale-green snake (*Dryophis fulgida*) so perfectly imitating the stem of a liana that it deceived even his practised eye at first sight;[4] and we must, doubtless, refer to the same cause the verdant colour of the grass-snakes mentioned by Dr. Günther. But the noticeable point here, as in the case of the butterflies, is this, that while we find a prevailing imitative greenness, apparently for protective purposes, we so often find a mixture of crimson, blue, yellow, orange, or metallic iridescence, whose function seems to me purely attractive. We shall notice similarly, when we come to look at the parrots, that their prevailing ground-tint is likewise green, but that they indulge in every variety of brighter pigments in a decidedly conspicuous manner. My own observation of West Indian lizards would certainly lead me to say that their colours were far more likely to betray them than to protect them, even in their native haunts.

[1] Naturalist in Nicaragua, p. 321.

[2] See also Tropical Nature, p. 111, *seq.*

[3] Naturalist in Nicaragua, p. 12.

[4] Naturalist on the Amazons, p. 99.

Birds, however, offer the best evidence of all. It will be desirable to mark briefly the most conspicuous instances, and then to give the minor cases in detail.

The birds of prey—eagles, hawks, and falcons—and the carrion birds—vultures, condors, and (since we are speaking of habits only) ravens or adjutant storks—are all dull greyish or blackish birds,[1] and their colouring may be compared to that of the flies and crocodiles. Nocturnal birds, again, such as owls and goat-suckers, show considerable analogies to moths and other night-flying insects.[2] In fact, all the raptores, of whatever habit, and almost all birds of similar habit elsewhere, are nearly or quite destitute of decorative colouring.

On the other hand, among the insessores we find an immense number of the most brilliant of all organic creatures. Especially remarkable are the humming-birds and the sun-birds. Now, Prince Lucien Bonaparte has abundantly shown that the former family are really the allies of our dingy northern swifts, and that the sun-birds are not at all connected with them genetically. But both families feed upon the mixed nectar and insects which they catch in bright-coloured entomophilous flowers, and both are equally noticeable for their exquisite metallic gloss, their varied hues, and the profusion of their decorative devices, such as crests, ruffs, feather lappets, and long tail-plumes. Is it not a significant fact that these two families, one in the western hemisphere and the other in the eastern, separately developed from dingy ancestors, should have acquired exactly the same exquisite plumage under exactly like conditions of food? We can hardly resist the inference that a taste for colour has been aroused

[1] I am aware that all such generalisations will be attacked by bringing up isolated instances, such as the king-vulture, who may lay some claim to be moderately coloured; but I must beg the reader to take each group in its ensemble, and not to look at single cases.

[2] While following approximately the real biological order in these cases, I do not scruple to introduce analogous instances from any other tribe when necessary.

in their constant search after flowers, and that this taste has reacted through sexual selection upon their own appearance.

Next in importance to these two families come the parrot group. These are either fruit-eaters, or else, as in the case of the lories, they feed upon nectar. And here I venture to borrow Mr. Wallace's words. "No group of birds," says he—"perhaps no other group of animals—exhibits within the same limited number of genera and species so wide a range and such an endless variety of colour. As a rule parrots may be termed green birds, the majority of the species having this colour as the basis of their plumage, relieved by caps, gorgets, bands, and wing-spots of other and brighter hues. Yet this general green tint sometimes changes into light or deep blue, as in some macaws; into pure yellow or rich orange, as in some of the American macaw-parrots (*Conurus*); into purple, grey, or dove-colour, as in some American, African, and Indian species; into the purest crimson, as in some of the lories; into rosy-white and pure white, as in the cockatoos; and into a deep purple, ashy or black, as in several Papuan, Australian, and Mascarene species. There is in fact hardly a single distinct and definable colour that cannot be fairly matched among the 390 species of known parrots. Their habits, too, are such as to bring them prominently before the eye. They usually feed in flocks; they are noisy, and so attract attention; they love gardens, orchards, and open sunny places; they wander about far in search of food, and towards sunset return homewards in noisy flocks, or in constant pairs. Their forms and motions are often beautiful and attractive. The immensely long tails of the macaws, and the more slender tails of the Indian parraquets; the fine crest of the cockatoos; the swift flight of many of the smaller species, and the graceful motions of the little love-birds and allied forms; together with their affectionate natures, aptitude for domestication, and powers of mimicry—combine to render them at once the most conspicuous and the most attractive of all the specially tropical forms of bird-life."[1]

Even the minor variations of these three great groups—the humming-birds, the sun-birds, and the parrots—show us a like result. For there is one sub-family of the former group—the Phaëthornidæ—which have not taken to flower haunting, but which catch minute insects on exposed situations; and these are described by Mr. Wallace, not in that language of sapphire, ruby, and amethyst which is lavished on their congeners, but simply as "small brown humming-birds."[2] "The members of all these genera," says Mr. Gould in his magnificent work on the Trochilidæ, "are remarkable for being destitute of metallic brilliancy, and, as their trivial name of 'hermits' implies, for affecting dark and gloomy situations. They constitute perhaps the only group of the great family of humming-birds which frequent the interior of the forests, and there obtain their insect food—some from the underside of the leaves of the great trees, while others assiduously explore their stems in search of such lurking insects as may be concealed in the crevices of the bark. It has been said that spiders constitute the food of many species of this group." And he adds significantly a few lines further down, "in the colouration of their plumage both sexes are generally alike."[3] Then, again, we learn of the Arachnotheræ, or spider-hunters, "which are sun-birds without any metallic or other brilliant colouring," that they hunt for food among the anemophilous and uncoloured blossoms of the palm-trees.[4] So, too, among the sombre vegetation of New Zealand an anomalous night-parrot (*Strigaps habroptilus*) is found, which lives in crevices of the ground, or in rocks

[1] Tropical Nature, p. 100.

[2] Ibid., p. 136.

[3] Monograph of the Trochilidæ, Introduction, p. 36.

[4] Of course the other humming-birds and sun-birds also live mainly upon insects found in flowers, but this does not militate against the argument here employed, for the brilliant mass of colour would naturally be to them the empirical symbol of food, and they cannot possibly distinguish between the circumstances which lead to the presence of honey and of insects in the blossoms they suck.

and tree-roots, only coming out after dark, and its colour is spoken of as "dull yellowish green."[1] Here one may feel almost certain that the primitive bright hue has become faded and dingy owing to the altered habits of the bird, which would effectually prevent the action of sexual selection.

Scarcely less interesting are the group of pigeons, which fall under two principal heads, so far as our present purpose is concerned, the fruit-pigeons and the ground-pigeons. The former class are extremely brilliant in their colouring, comprising a large number of the most beautiful known birds; while the latter almost always display sombre dove-colours, slates, and browns.[2] Now, the fruit-pigeons are "especially arboreal in their habits," and "their nourishment consists for the most part of fruits:" while the ground-pigeons feed almost entirely on seeds.

The toucans form another group in which like adaptations occur. They live nearly altogether upon fruits, though they also devour birds' eggs, fish, reptiles, and insects, to a slight extent. The exquisite colours which adorn their large bills, besides the varied black, white, green, red, and yellow of their plumage, are well enough known to call for no further detail.[3]

Several other families, allied to one or other of the preceding groups, are almost equally noticeable for their magnificent colouration. First on the list may come the Australian honey-suckers, and the plantain-eaters of Africa, whose name sufficiently proclaims their habits. Next, we may place the allied genus of Touracos, "generally of a green colour, with the quill feathers of the wing and tail violet or red." The birds-of-paradise, too well known to need description, feed on fruits, though some species are flower-suckers. The barbets, known by such

[1] Hochstetter's New Zealand, p. 167.

[2] Jerdon, Birds of India, vol. ii. p. 446.

[3] See on the colours and food of toucans, Gould, "Monograph of the Ramphastidæ," *passim*.

expressive names as golden-throated, blue-throated, crimson-breasted, and so forth, live almost exclusively on fruits and the buds of flowers. The ornithological reader will have no difficulty in filling in other cases for himself.

Again, many of the tropical birds, less brilliant on the whole than these pure vegetable-feeders, yet still remarkable for beautiful colouration, live upon a mixed diet of fruits, tropical insects, eggs, lizards, and other bright-hued foods. "Owing to the prevalence of forests and the abundance of flowers, fruits, and insects," says Mr. Wallace, "tropical, and especially equatorial, birds have become largely adapted to these kinds of food; while the seed-eaters, which abound in temperate lands, where grasses cover much of the surface, are proportionately scarce." To this cause, I believe, we may trace the general brilliancy of tropical as compared with temperate birds, especially among the great groups of passeres and picariæ.

Among other instances, which I can only note briefly, may be mentioned the trogons, which are in all cases conspicuous for their varied beauty; but those which inhabit America are more gorgeous than the Indian species; and fruit forms part of the diet among the former, while that of the latter is mainly composed of insects.[1] Mr. Gould mentions that the stomach of *T. collaris* contained on dissection "fruits and caterpillars."[2] The swallows of temperate climates are plainly coloured, as might be expected from the nature of their food; but their allies, the rollers, decked in gorgeous violet, blue, and green, live upon "insects and fruits" in sub-tropical countries: and with them may be included the exquisite todies, with their green plumage and gay scarlet breasts.[3] The lovely motmots of tropical America and the West Indies feed upon insects, fruits, and lizards.[4] The diet of

[1] Jerdon, Birds of India, vol. i. p. 200.

[2] Monograph of the Trogonidæ, *sub voc.* See also under *T. melanopterus* and *T. pavoninus.*

[3] Gray, Genera of Birds, i. 62.

[4] Ibid., i. 77.

the *Eurylaimus* is described as consisting of "insects, at times berries and fruits."[1] The omnivorous crow family are dingy creatures, usually with no colouring save black and white; but their near relations, the jays, have a much more vegetal diet, and are often decorated with very striking colours. In summer they "visit gardens, tempted by the cultivated fruits," and they also feed on eggs and insects. The hornbills live almost entirely on fruit and eggs; and their large beaks are coloured somewhat after the same fashion as the toucans. But I shall not extend this list, which might be easily enlarged with numberless other instances. I shall ask the reader instead to glance over any ornithological work, and to notice the universal coincidence of coloured food and coloured plumage for himself.[2]

On the other hand, most of the seed-eating and omnivorous birds are dull brown, black, or otherwise dingy in their plumage. All our own small field-birds may be roughly included under this generalisation. Such are the starlings, finches, sparrows, larks, thrushes, ouzels, wagtails, titmice, nightingales, swallows, and martins. Many of these live upon seeds and grains; others search for larvæ, insects, mollusca, and other small animals, often amid dung or like refuse. Even amongst these, we find instances which bear out our general theory. Thus the thrushes as a rule are very modest in their plumage; but the fruit-feeding orioles have comparatively bright hues. So, too, while most of the finches are plainly clad, the forestine rose-finches have exquisite tints of pink and crimson. Again, among our own birds, the few brighter-coloured species point somewhat in the same direction: for the bullfinch, the most notable of them, has very arboreal habits, feeds upon various berries, and attacks flower-buds in gardens to such an extent that it has be-

1 Gray, Genera of Birds, i. 65.

2 I find the number of cases collected in my notes quite too bulky for inclusion here in full, so I have only selected hap-hazard a few of the most striking.

come a perfect nuisance to gardeners: and I find the food of the Bohemian chatterer specified as consisting of "the berries of the mountain ash, hawthorn, and ivy," together with the fruit of the juniper.

Intermediate between these two classes of brilliant and dingy birds come a number of moderately-beautiful tribes, some of which nearly equal the parrots and humming-birds, while others scarcely rise above the level of European song-birds. The birds of this division are more or less forestine in their habits, live amid a very varied environment, and feed upon insects (often very brilliant) or vegetal matters, including seeds, fruits, bulbs, flower-buds, and leaves. Besides the rollers, todies, and motmots already mentioned, we may class here the cuckoos, wood-peckers, pastors, grossbeaks, manakins, *pachycephalinæ*, flycatchers, hoopoes, bee-eaters, jacamars, and kingfishers. It would take up too much space to specify all instances in full; but I have satisfied myself that a general connection may be traced amongst them all, on the average, between bright food and pretty colouring.

The cases so far examined belong to the great central group of birds which composes the common orders Columbæ, Scansores, and Passeres: we may glance briefly at the more divergent orders, whose habits have produced a very different structure. The swimming birds, with webbed feet, are seldom conspicuous for their colouring. The marine species (as penguins, auks, puffins, grebes, gulls, and albatrosses) are more or less whitish, with a toning-down of black or grey. But the ducks and flamingoes, which live amid a much more varied environment, and feed off more diversified food, are often adorned with conspicuous colours. These, I confess, cannot always be explained by our present principle.

The wading birds (snipes, storks, cranes, herons) display for the most part only cinereous or other dingy plumage. *Psophia*, however, a brilliant South American crane, is a tropical forestine bird, and feeds on fruits and grains.[1] The scarlet ibis of the Amazons has also the common brilliancy of its country, which may be equally noticed in the roseate spoonbill. Here, as elsewhere, I must ask the reader to take each order or family in the mass, omitting such aberrant cases as do not readily admit of explanation.

The running birds (ostriches, emus, cassowaries, apteryx) have little beauty of colouring. The most brilliant among them, the cassowary, whose naked head and neck are tinted with red and blue, is also the most frugivorous of its order, feeding upon fruits, herbage, and seeds; while the dingiest of all, the apteryx, has purely nocturnal habits, and feeds upon insects.

The only real difficulty is presented by the gallinaceous birds, and these must be allowed at first sight to offer a great obstacle to our theory. But even here a little consideration considerably modifies the opinion we form at a cursory glance. To begin with, most species, like the grouse, partridges, quails, and guinea-fowls, are by no means remarkable for the purity or intensity of their hues. There is really only one family, that of the Phasianidæ or pheasants, including the turkeys and peacocks, which can lay claim to much beauty on the score of colour. Even among the pheasants themselves many species are far from brilliant; and when we come to compare the whole family with that of the parrots or the humming-birds, we shall find that the peacock alone can fairly come into competition with the typical fruit-eaters and flower-feeders. Moreover, the pheasants as a group are thoroughly forestine birds; they pass their life in the midst of brilliant objects, and many of these serve them as food. Turkeys in the wild state feed on grain, berries, fruits, grass, and insects, being especially fond of locusts and grasshoppers. The diet of the true pheasants comprises the same varied items, and Yarrell mentions blackberries, sloes, haws, and acorns as among their favourite viands in English copses.

[1] Gray, Genera of Birds, iii. 550.

The forests of the Himalayas and of the Malay Archipelago, with their great brilliant fruits and flowers, and their exquisite insects, form the haunts of the most beautiful species of pheasants. The peacock in the wild state is also a jungle-frequenter, and feeds upon grain, fruits, and insects. On the whole, I think it may be fairly said that the gallinaceous birds, though not strong supports for our general theory, may be regarded as friendly neutrals at least. The dingy species are skulkers in underbrush, who feed off small grain, seeds, bulbs, and insects; while the brilliant species are tropical or subtropical forestine birds, whose food comprises many bright-coloured objects, both animal and vegetal.[1]

Passing on to the mammalia, we find facts of the same sort presented on every side. The whole lower series, whether among marsupials, pachyderms, cetacea, ruminants, carnivora, or insectivora, show us almost uniformly tints of black, brown, grey, or dingy yellow. It is true that many animals, like the zebras, tigers, spotted deer, and giraffes, have very noticeable alternations of light and dark shades, but they do not yield us pure spots of green, blue, red, or yellow. When we come to the essentially arboreal mammals, however, the tree rodents and the quadrumana, we get many comparatively brilliant species. The squirrels are often remarkable for their beautiful colours, and the so-called flying-squirrels call for special notice in this respect. The contrast between these pretty little creatures and their allies, the mice, rats, beavers, and water-voles, strongly brings out the peculiarity of their hues. So, too, the purely frugivorous monkeys give us a variety of colour which we find nowhere else among the mammalia: and in the scarlet faces of many among them, or most remarkably of all in the bright red and blue of

[1] It is worthy of note that one Sub-Antarctic species, *Chionis alba*, living on the sea-shore, has the characteristic colouring of the gulls or other swimmers, while its external configuration long caused it to be included among the waders.

the mandrill, we have the only *pure* tints which are to be found in the whole class. Compared with the nocturnal bats, we see at once the action of sexual selection.

Lastly, I should like to add that while I attribute special importance to the nature of the food, I do not deny that the whole environment must have a considerable modifying influence upon the tastes, and therefore upon the colouration of each species; and accordingly I freely allow the general truth of my friend Mr. Romanes' theory upon this subject, though I cannot agree with him in setting down the growth of tastes to mere association.

I am aware that this long catalogue, by mixing up the more certain with the less certain instances, has presented the evidence in its weakest light. To redress the balance, then, let us recapitulate the main facts from another point of view.

Flowers are the most brightly-coloured of all vegetal productions. Among the creatures which find their food in flowers may be mentioned butterflies, the most brightly-coloured of all insects, besides humming-birds and sun-birds, the most brightly-coloured of all vertebrates. Other flower-haunting insects are the rose-beetles, loveliest of all the Coleoptera, and many more of the handsomest species. Other flower-haunting birds are the lories, far the most beautiful among the parrot tribe, and some of the birds-of-paradise. The pretty little barbets also feed in part on flowers. The butterflies, rose-beetles, humming-birds, sun-birds, and lories have been highly modified in adaptation to the blossoms in which they find their food.

Fruits rank second in beauty among vegetal organs. First in the list of creatures which feed upon fruits may be mentioned the whole tribe of parrots, macaws, and cockatoos, the brightest in hue of all birds, except the flower-feeders. Next we may place the toucans, with their gaudy beaks, and with them the hornbills. Then come the fruit-pigeons, whose gorgeous tints contrast strongly with those of their seed-eating congeners. After these succeeds a whole host of orioles, blue-birds, birds-of-paradise, plantain-eaters, and less conspicuous fruit-feeders, every one of whom has some beauty of colouring which recalls its habitual food. Again, the frugivorous bats, and the fruit-eating quadrumana, including the gorgeous mandrill, are the most highly-coloured of the mammalia. Finally, the frugivorous lizards must not be forgotten among the list. Of these, the parrots, toucans, and fruit-pigeons have been specially modified to suit their peculiar food.

Third in point of colouring we may place the insects themselves, which have based their own beauty upon that of the flowers. The creatures which prey upon these may be divided into two classes, the partly frugivorous, and the wholly insectivorous. Among the former we may specially note as brilliantly-coloured the rollers, todies, motmots, many trogons, hoopoes, some birds-of-paradise, and jays. Among the latter we may note the dragon-flies and tiger-beetles, in the insect world itself; the jacamars, bee-eaters, fly-catchers, and many other bright small kinds of birds; and the *Draco*, with many less brilliant lizards. On the whole, these various animals are inferior in beauty of colour to the flower-feeders or fruit-eaters, but are still very bright in their hues. It should be further noted that most of them are closely allied with frugivorous or flower-haunting species, from which they may in some cases be descended, and that many live habitually in the midst of an environment distinguished for the general brilliancy of its colours.

Next, we may descend to these same creatures themselves, looked upon as tertiary causes of colouring in others. Among the bright objects which feed upon these birds or reptiles may be noticed many brilliant snakes and some lizard-eating birds. These, too, live amid an environment of considerable beauty.

Last on the list we may place the marine creatures, fishes or crustaceans, which pass their time among the gorgeous productions of tropical seas, and whose own colouring may possibly reflect that of their varied and exquisite surroundings.

Now let us look at the reverse picture of those classes which are specially deficient in pure and conspicuous colouring.

First in order of ugliness must be placed the carrion-feeders, who live upon decaying bodies or animal excrements. Among insects, we may notice the flies which swarm about carcasses or dung, several dingy beetles, and all the other ugly creatures which we always surprise in such situations. Among birds, the vultures, condors, turkey-buzzards, and other like *obscenæ volucres*, show correspondingly dull colours. Among mammals, the hyenas and jackals may fall nearly under the same category. It is worth notice that all these creatures have for naturally frugivorous man a certain weird and uncanny appearance, which seems not entirely dependent upon association with their hideous mode of life. It may also be observed that those races of mankind which have most fully adopted the habit of feeding upon carrion or filthy prey, such as worms, insects, &c., are often the blackest, most squalid, and least æsthetic of the whole human species.[1]

Second in dinginess rank the nocturnal animals. Among insects, we have the moths, and many such tribes as earwigs and cockroaches. Among birds, we get the owls, which exactly reproduce the moths in colour; besides the goat-suckers, the apteryx, and numerous other aberrant types. Among mammals, we have the mass of bats, and several quadrumanous animals. All these are remarkable for a certain general murkiness of hue, which cannot otherwise be described, but which can be *felt* as differing from the hideousness of the carrion-feeders on the one

[1] For the evidences on which this assertion is based, too numerous for quotation here, see Mr. Herbert Spencer's "Descriptive Sociology," under heading "Æsthetic Sentiments," *passim*.

hand, and the cinereous tone of the carnivorous birds on the other. It should further be noted that the owls and bats have eyes specially modified for darkness, by the absence of the cones, which we have seen reason to conclude are the special organs of colour-perception; while I have already pointed out a corresponding structural peculiarity in the eyes of nocturnal insects. The subterranean mole may perhaps be grouped in the same class.

Third in this connection we may place the rapacious animals generally. Fishes supply us with the shark and pike. Reptiles include the crocodiles and many snakes. Birds yield instances in the raptores as a whole,—eagles, hawks, falcons,—and in isolated cases such as the shrike. Mammals add the wolves, bears, and insectivores. The larger cats, however, together with the green snakes, must be specially excepted, their colouring, as we shall see hereafter, being protective in its arrangement. So, of course, must be the animals already enumerated among the brilliant class, which feed upon unusually bright-coloured prey.

Other cases must be roughly enumerated in a single paragraph. The larger marine creatures are usually dull: as witness whales, porpoises, walruses, seals, and turtles. Fresh-water animals are less bright than the smaller marine and terrestrial fauna: take for examples river-fish, fresh-water molluscs, water-beetles, otters, voles, coots, and most water-fowl. The mass of herbivores are quiet in colouring, though often pretty according to our developed Aryan taste. Omnivorous animals, like crows, pigs, and men, are not usually bright in their tints. Seed-eating birds have mostly grey or neutral plumage. Marine birds are, as a rule, whitish or grey. In short, the immense majority of animals which do not feed on bright-coloured food are of plain hues, in which black or white predominates, in certain muddy mixtures, with very little tinge of red, yellow, green, or blue, and with *no* spots, bands, or markings of pure analytic colours.

Lastly, intermediate between the two classes of brilliant and dull-coloured animals, we get what may be called the transitional stage. This stage shows a general tendency to pure colours, more or less subdued by plainer intermixtures; but it does not often exhibit perfectly unmixed shades of crimson or azure. It is represented in many insects, especially among the Lepidoptera and Coleoptera; in the remaining insessores and gallinaceous birds; in squirrels, monkeys, and many frugivorous mammals; and in numbers of snakes, lizards, and amphibia. Most of these may be said to hover on the border between bright and dingy foodstuffs, varying from flies, grubs, slugs, brownish seeds, and small grey birds or mammals, to gay fruits, butterflies, birds' eggs, banded snails, bright little reptiles, and birds of handsome plumage. As a whole, an approximate correspondence can be traced between the average brilliancy of their food and the average brilliancy of their own colouring.

If all these be mere coincidences, they seem to me without exception the most extraordinary coincidences ever observed in nature. But even a list such as this cannot at all adequately represent the real state of the case. I may therefore be pardoned if I mention that the generalisation here so insufficiently enforced has been thrust upon me by three separate sets of observations. First came my own constant observation, that within the sphere of my daily experience, in walks and excursions, in Europe, North America, and the West Indies, I found such a correspondence between bright food and bright colouring, or dull food and dull colouring, to obtain in a vast majority of cases. Secondly, visits paid for the purpose to the Zoological Gardens, the British and other Museums, and the various aquariums, in order to satisfy myself as to such correspondence, greatly increased my belief in its truth. After examining the several brilliant species, I made inquiry into trustworthy books as to the nature of their food, and I almost always found that the rough generalisation I had provisionally framed was thus greatly supported. I may add, too, that the mass of specimens, as seen in a garden or a cabinet, produces a far more vivid impression on the mind than is possible from the mere mention of isolated names. Thus a single instance, like that of the peacock or the flamingo, has great weight under ordinary circumstances, when thought of in isolation; but when one turns from a case full of the gallinaceous birds or the waders, to a case full of flower-haunting humming-birds or fruit-eating parrots, the difference in the whole average of instances is seen to be simply infinite. Accordingly, I would strongly urge those who wish to judge of my theory for themselves, to make such careful comparisons in person, at some one of our great zoological collections. Thirdly and lastly, during the whole course of my reading in the works of traveller-naturalists, I have been invariably struck by the same connection of food and hue. Especially has this connection been thrust upon me once more by Mr. Wallace's admirable work on "Tropical Nature," which has appeared since the present volume was wholly planned, and in great part written. And since this theory is the part of my work to which I myself attach the greatest importance, and for which I expect the greatest amount of hostile criticism, I venture to add a few typical passages from my notes, gathered from those works which have so often stood us in good stead already, and jotted down in passing, while the theory was still vaguely evolving itself in my mind. They may help to show the reader the style of suggestion which comes upon one from every side with reference to this subject.

Of the fruit-pigeons, Dr. Jerdon says, "These pigeons are of very large size, with rich and metallic colours;"[1] but of the ground pigeons and doves, which "feed chiefly on grains," he observes, "they are of more dull and sombre colours."[2] Mr. Wallace speaks over and over again of

[1] Birds of India, vol. ii. p. 455. [2] Ibid., p. 461.

similar species, such as the lovely little fruit-eating *Ptilinopus pulchellus*, which "is of a beautiful green colour above, with a forehead of the richest crimson, while beneath it is ashy white and rich yellow, banded with violet red."[1] Then we have the exquisite Nicobar pigeon, which eats "fallen fruits,"[2] the "very handsome fruit-pigeon" (*Carpophaga concinna*), which lives on nutmegs,[3] and the "pretty little flower-pecker" (*Prionochilus aureolimbatus*), whose name sufficiently declares its golden markings. Once more, *Scissirostrum Pagei* belongs to a family generally dull, but has yellow bill and feet, and a tail of "vivid crimson;"[4] and on inquiry, we see that it feeds upon fruit. Soon after, we read concerning a flock of the "fine crimson lory (*Eos rubra*), a parroquet of a vivid crimson colour," that "they settled down upon some flowering tree, on the nectar of which lories feed."[5] Then again we have the "large green barbets (*Megalæma versicolor*), something like small toucans, . . . whose head and neck are variegated with patches of the most vivid blue and crimson."[6] On another page we meet with a lovely small fruit-pigeon (*Ptilinopus roseicollis*), "whose entire head and neck are of an exquisite rosy pink colour, contrasting finely with its otherwise green plumage."[7] So, when we turn to Sir Emerson Tennant, we find the "very beautiful pigeon" *Carpophaga Torringtoniæ;*[8] the exquisite flowers, haunted by lovely butterflies; and the magnificent bats and flying squirrels, which feed on fruits. Mr. Bates similarly tells us how along the Amazons the butterflies were found in great brilliancy on the flowery parts,[9] while amongst them flitted "fiery red" dragon-flies; how "from the wild fruit-trees we often heard the shrill yelping of the toucans;"[10] how the pretty cigana (*Opisthocomus cristatus*), a gallinaceous bird, eats various wild fruits, and how at one place on the river, where he "was surprised

[1] Malay Archipelago, p. 528.
[2] Ibid., p. 345.
[3] Ibid., p. 291.
[4] Ibid., p. 274.
[5] Ibid., p. 297.
[6] Ibid., p. 28.
[7] Ibid., p. 123.
[8] Ceylon, p. 174.
[9] Naturalist on the Amazons, pp. 20, 274, *et al.*
[10] Ibid., p. 26.

at the number and variety of brilliantly-coloured butterflies," he also noticed the "glossy-green beak and rose-coloured breast" of a "beautiful bird" (*Trogon melanurus*), and the "golden-bronze and steel colours" of a jacamar (*Galbula viridis*), which fed on these very insects.[1] On the other hand, he notes how, near Santarem, "the pastures are destitute of flowers, and also of animal life, with the exception of a few small plain-coloured birds."[2] I could multiply these instances by dozens, but I only select the first which I find on my notes, to show the sort of evidence which suggested and supported the theory,[3] and by observing which it may be most easily confirmed. Indeed, whenever I find mention of any brilliant creature, be it Indian Goliath-beetle,[4] South-American longicorn,[5] scarlet-faced monkey,[6] gay-coloured squirrel,[7] handsome bats,[8] or fairy blue-birds,[9] I almost always notice, either coupled with the fact, or on further search, that the animal in question feeds upon bright-coloured food.

It will perhaps seem like pushing the conclusion beyond reasonable limits if I go on to say, that in some cases one may even possibly detect a correspondence in actual tint between the animal and its food. Yet even this appears not wholly impossible. Of course no stress can be laid on some two dozen or so of such instances, some of which may be really protective; but the hint is worth throwing out, for future verification or disproof, as the case may be.[10]

[1] Naturalist on the Amazons, p. 71.

[2] Ibid., p. 183.

[3] It is worth while, perhaps, to add that the original idea of the causal connection between flowers or fruits and a taste for colour, which I first worked out in my "Physiological Æsthetics," and afterwards in this volume, was set up in my mind while watching the humming-birds, tropical robins, butterflies, beetles, and lizards, together with the blossoms, berries, and capsicums, in my own garden in Jamaica.

[4] Hooker's Himalayan Journals, ii. 98.

[5] Bates, *ubi supra*, p. 110.

[6] Ibid., p. 326.

[7] Wallace, Malay Archipelago, p. 123.

[8] Sir Emerson Tennant, Ceylon, p. 135.

[9] Jerdon, Birds of India, vol. ii. p. 105.

[10] I had collected a few cases, but omit them, as being hitherto insufficient.

And now that we have completed this part of our inquiry, let us once more return to Mr. Wallace's objection against sexual selection, from the root upward. When we were considering its applicability to insects, I pointed out that the "theory of typical colours" really suffices to cover the whole difficulty; and the same argument will apply to vertebrates; for if recognisability is a requisite of the typical colouring, it may well happen that those species which feed on brilliant objects, being always on the look-out for patches of colour, will be mutually attracted to one another; and the taste thus set up and strengthened from generation to generation may become an additional cause for differentiating the nascent species from others of different habits. As the taste for brilliancy and the frugivorous mode of life will go hand in hand with one another, it will naturally happen that some variety of colour will become the recognised differentia of the particular species, whereby its members mutually know their own fellows from all other kinds. And at the same time, inasmuch as all species of flower-feeders and fruit-eaters are not coloured alike, and have not the same ornamental adjuncts, I fail to see the force of Mr. Wallace's argument that all individuals seem to pair off in the long run; for the æsthetically-endowed individuals would pair off with one another, while the æsthetically-deficient would be left for their likes; and the difference thus initiated, correlated as it must necessarily be with other peculiarities of taste and habit, would become in turn the starting-point for a fresh differentiation. Indeed, if I may say so without presumption concerning so great a naturalist, Mr. Wallace seems to me here to have fixed his eyes rather upon the *product*, the made species, than upon the *process*, the species-making.[1]

Moreover, it is noteworthy that among these same brilliant creatures, which owe their colours ultimately to

[1] See especially "Tropical Nature," p. 206.

their bright-hued food, we find the greatest profusion of other apparently æsthetic and sexual ornaments. The butterflies, besides their colours, are remarkable for their queer tails and other appendages, as well as for those allurements of scent which F. Müller has pointed out. The beautiful fishes are likewise the species in which strange excrescences occur. The lizards have an immense number of ornamental devices, like pouches, knobs, and horns. The humming-birds and sun-birds are distinguished by their ruffs, crests, lappets, and tail-feathers. The parrots and birds-of-paradise affect similar tricks of plumage; which are also found in the hoopoes and many of the semi-brilliant class. The handsome gallinaceous birds have combs and wattles. And while we find few such ornamental modifications among the lower mammalia, it is a fact pregnant with import that the frugivorous and arboreal rodents or quadrumana repeat the very same peculiarities of crests, tufts, and beards which are so common amongst the similarly-environed forest birds. Any one who will take the trouble to look through the immense collection of instances in Mr. Darwin's "Descent of Man," will see at a glance that the most brilliant tribes are also, on the whole, the most ornamented.

On the other hand, one may hazard the rough generalisation, that the animals which appeal to their mates by the sense of hearing are not those which appeal by the sense of colour. The stridulating insects and the singing birds are usually plain in their external appearance. It might seem as though the habits of some races had led them to attach more importance to sounds, while the habits of others led them to attach more to colour. In any case, we may be quite certain that no such taste is fortuitous and isolated. It *must* bear some definite relation to the general mode of life throughout the race.

One more question remains. Mr. Wallace observes with great truth that colour may be regarded as a normal product of organisation, whose presence in animals does not need to be explained so much as its absence. But the difficulty at once crops up—what colour? I have not space fully to follow up this ultimate problem; but we may find room for a few brief suggestions.

Almost all the ornamental appendages of animals are modifications of the skin or its equivalent. They are found most frequently and strikingly in the male sex: and they are most conspicuous during the breeding season. Whatever we may think of their functions, we must agree that they are, on the whole, products of high vitality. They represent part of the excess of nutriment over expenditure.[1]

But these dermal adjuncts do not probably take away anything from the effective energies of the organism. As Mr. Lowne well puts it, in his able and suggestive work on "The Philosophy of Evolution," the formation of pigments and like matters is apparently due to the waste-products of the other organs. "The dermal appendages of reptiles and the feathers of birds, rich in pigment and nitrogen, are probably entirely excrementitious to the other tissues, and, without doubt, depend in great part for their origin on the solid nature of the excretion of the kidneys. Birds especially, leading a very active life, excrete material rich in nitrogen; and the feathers, which are shed periodically, enable them to throw off that element without overtaxing their renal organs." And again, "A given pabulum being supplied, certain essential structures are nourished, and the residue is economised in the production or modification of other parts, often giving rise to ornamental appendages or bright colours; whilst the action of the same principle correlates the modifications of different organs or parts with each other."[2]

Hence we can understand why the more active and energetic sex should possess a greater number of highly

[1] Tropical Nature, p. 194.

[2] The Philosophy of Evolution, p. 75. The whole of the chapter on Nutrition, in which these passages occur, should be consulted with reference to this interesting question.

developed dermal adjuncts, and should often display much brighter colours than the females. We can also see why these integumentary modifications should be largest and most expanded in the most active races, such as butterflies, birds, flying-lizards, and arboreal mammals; while conversely, the possession of these very organs, in the case of flying animals at least, is itself a cause of their increased locomotive power. Here we notice a remarkable instance of that close interaction between structure and function which has been pointed out by Mr. Herbert Spencer,—the function first developing the structure, and each increment of structure permitting increased function, which once more becomes in turn the parent of further structural modifications.

But we do not yet see why the pigments which are deposited in the dead processes of the skin, should possess one colour rather than another. The answer to this question must ultimately depend upon the habits and needs of each species. Where protective colouring proved most useful to the race, it would be acquired, as Mr. Wallace has well pointed out, among the infinite possible varieties of these very changeful substances; but where attractive hues were of greater advantage, they would be retained by sexual selection. Mr. Wallace has shown why *pigment* should be developed in the feathers of birds and the scales of butterflies; but it does not seem to me that he has sufficiently shown why one pigment *rather than another* should be developed. The black colouring of the crow, and the dusky wings of owls and moths, are just as much products of that integumentary modification on which he lays so much stress, as are the bright hues of butterflies or the plumage of parrots. In fact, it seems to me that Mr. Wallace does not sufficiently distinguish between pigment and bright pigment.

On the whole, therefore, while fully recognising the value of Mr. Wallace's arguments with regard to the origin of pigments, the relation of ornament to activity, the protective use of subdued colour in certain cases to one or other sex, and so forth, I am still inclined to think that the general coincidence between bright food and bright colour noticed above, does really warrant a belief in such a simple form of sexual selection as that here advocated. Especially am I inclined to suppose that differences of taste thus originated may themselves be active differentiating agents for the production of new species with correlated habits.

A few further suggestions and observations of a general character may here be added, merely as hints for those who wish to pursue the subject independently.

The brightest colouration and most developed ornamental adjuncts seem to be confined to very small and active animals, such as butterflies, beetles, humming-birds, sun-birds, and flying-lizards. Those of the somewhat larger creatures, parrots, toucans, fishes, snakes, and greater reptiles or amphibia, are, on the whole, not quite so brilliant or so largely developed; and the activity of these species is less than that of the preceding group. On the other hand, the largest animals of each great division, among vertebrates at least, show a decided tendency toward very dull and inconspicuous hues; take as examples the sharks, sturgeons, sun-fish, tunny, and cod; the gigantic salamander; the crocodiles, turtles, and great snakes; the ostriches, emus, eagles, condors, storks, swans, and penguins; the whales, walruses, elephants, hippopotami, rhinoceroses, gorillas, bears, buffaloes, and elks. These are mostly slow and inactive animals, and they are also little distinguished for expanded epidermal modifications. Indeed, it may be said, roughly speaking, that all very large birds or mammals show more or less tendency to lose or minimise their feathers or hair.

Those larger animals which, like the mandrill, the cassowary, and the king-vulture, display brilliant colouring, have it disposed in small patches on a particular portion of the body, not over its whole surface.

Flying animals seem to show special æsthetic tastes. At least, they are largely provided with apparent sexual allurements. Such are the colours of birds, flying-lizards, and butterflies; the perfumes of some Lepidoptera; the stridulating organs of insects and the song of birds; and the frills, ruffs, crests, lappets, or tails of birds and butterflies. Of course, the origin of these may be largely accounted for by the causes which Mr. Wallace assigns; but their selection and persistence seems to imply an unusual æsthetic sensibility. It is among birds alone, too, that we find clear evidence of æsthetic feelings, as with the magpies and bower birds. Now, is it not possible that the comparative security which each flying race obtained on its first development, permitted the various species to indulge their taste to a greater degree than would have been the case with terrestrial creatures.[1] Would not flying creatures be more likely to notice and follow the attraction of such a sense-stimulation than sluggish terrestrial animals? And might not the introduction of predatory species at a later date, capable of preying on these classes, afterwards modify the colouration or other sexual allurement according to varying circumstances? For example, may not the growth of insect-eating birds have affected butterflies in various ways, so as to preserve those with protective or warning colours, while yet leaving many traces of the primitive sexual colouration? or may not the presence or absence of hawks and birds of prey have determined the development of song or colour respectively as an allurement in each species of bird? Does not the abundance of coloured animals in certain isolated lands, lying close to great continents, point toward the conclusion, that where special immunity from enemies exists, the æsthetic fancy can be more implicitly followed? And may not Mr. Wallace's

[1] "The most conspicuous pigeons, whether by colour or by their crests, are all found in countries where they have the fewest enemies."—Wallace, Tropical Nature, p. 103.

own remarks upon the humming-birds of Juan Fernandez possibly bear the same construction?

A similar hint may be thrown out with regard to fish, which bear somewhat the same relation to the other inhabitants of the ocean as flying creatures bear to the terrestrial animals. Indeed, the analogy between the fins of a gurnard and the wings of a butterfly must have been forced upon any one who has seen those exquisite fish in an aquarium. Again, the whole group of higher arboreal mammals have some considerable likeness to birds and the other winged animals in the activity of their movements, and the comparative security of their elevated position, while their tendency to produce such forms as the flying squirrels, the anomalurus, the galeopithecus, and the bats, shows how close the functional and adaptive resemblance may sometimes become.[1] Now, we have already seen that these arboreal animals are on the whole much more brightly coloured than other mammals, and we have also noted their tendency to develop hairy appendages, such as beards, ruffs, and top-knots. Moreover, some of them are also distinguished for their loud and piercing cries (produced in the case of the howlers by a special organ), which may be compared with the song of birds, and the presumably sexual noises given out by some other creatures.

Here, too, we see a striking analogy between the development of the sense of sight in general and of the colour-sense. For eyes, as we observed in Chapter iii., are most developed in the most locomotive races; and the colour-sense, the highest mode of sight, seems to be most highly developed only in exceptionally locomotive races. It would appear natural that only very mobile animals could derive any special advantage from the indications afforded by colour, and hence we may account for the

[1] The flying-squirrels are in all cases "remarkable for the vivacity of their colouring." So many of the other flying mammals are nocturnal that they may be safely left out of the account.

special share which flying insects and birds have borne in the production of bright-hued flowers and fruits, as well as for the frequent brilliancy of their own colouration.

Once more, it is worth noting that the hair of mammals seems very little adapted for the display of brilliant and pure pigments. The best that can be said of the hues produced is that they are bluish, rufous, or white, never that they are scarlet, purple, golden, or bright blue. The only cases in which mammals present really brilliant colouring are those like the mandrill and certain other monkeys, where the pigment is displayed beneath patches of bare skin, not in the hair or other epidermal modification.

After these remarks it is hardly necessary for me to add that I attach full weight to Mr. Wallace's general principles with regard to the importance of activity and of extended tegumentary surfaces as a groundwork for the production of colour or ornamental adjuncts. But I regard sexual selection, in the modified sense already noted, as the agency by which the particular colours and ornaments have been chosen from the whole possible number, and fixed in the typical specific mould.

Finally, it may be well to point out that a certain analogy seems to exist between the commonest animal pigments, and those of fruits and flowers. Some of the colours of animals fade after death, whence we may conclude that the substances of which they are composed remain in a state of comparative chemical instability. But most of the colours here treated of remain permanently after death, as may be seen in the case of stuffed birds and preserved insects. Accordingly, these bodies may be considered with great probability as comparatively stable in chemical composition, and as little affected by the danger of oxidisation. So we may perhaps guess that they are themselves oxidation products whose affinities are nearly saturated. If so, they might fall ultimately under the same category with the colouring matter of flowers, fruits, fading leaves, and other bright-hued vegetal products.

The reader will doubtless object that this chapter is far from being conclusive. I am well aware of its deficiencies in this respect, and shall feel fully satisfied if it only prove suggestive.

CHAPTER X.

THE INDIRECT REACTION OF THE COLOUR-SENSE UPON THE ANIMAL INTEGUMENTS.

In the last chapter we dealt with those cases in which the colour-sense of animals directly reacts upon the species themselves which possess it, by causing the more brilliantly-coloured among them to be specially favoured as parents of future generations. In the present chapter we must examine that other class of cases in which the colour-sense of one species indirectly reacts upon the appearance of other species, by causing all those individuals which present certain tints or spots to be destroyed, and only sparing those which present certain other tints or spots. In other words, the last chapter dealt with sexual selection; the present chapter deals with natural selection. In the first case certain special hues are favoured and, therefore, perpetuated; in the second case certain special hues are disadvantageous and, therefore, weeded out. Hence the action of the former cause is direct, the action of the latter indirect. Sexual selection actively chooses the beautiful, natural selection passively permits the fittest to survive.

Many of the cases which fall under the present head have already been cited elsewhere as proofs of the existence of a colour-sense in insects or vertebrates. Nevertheless, we may once more recapitulate them here, partly for the sake of formal completeness, but partly also to exhibit their mutual relations in a new and more systematic light. We shall thus be enabled with greater clearness to perceive how strong is the cumulative evidence which they afford for the general diffusion of a colour-sense throughout the animal world. At the same time, as this part of the subject has ere now been fully investigated by Mr. Darwin, Mr. Wallace, and numerous other well-known naturalists, I shall only attempt to give a very brief reasoned résumé of their labours, without references or details; referring those readers who wish for fuller information on the point to the original works from which my selection is made.

The colours produced (or rather spared) by natural selection fall under two groups, the Imitative and the Prohibitive.

By imitative colours we imply those which resemble the hues of some other body in such a manner as to insure protection or some other benefit for the species which possesses them. They may be useful for either of two purposes,—to escape the notice of enemies, or to deceive prey. In the first case, they enable the animal to avoid being itself devoured; in the second case, they enable it to devour others more easily, and so to secure a larger amount of food than less deceptively-coloured compeers. In the former instance, we must suppose that the majority of the original species which did not possess the imitative colouring have been discovered and devoured by enemies endowed with a colour-sense, while those which did possess the imitative colouring have continually survived. In the second instance, we must suppose that the individuals which had no imitative colouring have failed to secure sufficient food, through betraying their presence too readily to their prey, while those which had such colouring have successfully deceived their quarry, and so continually survived. We might compare the first case to that of a man who disguises himself in order to escape the observation of his enemies; and the second case to that of a man who hides himself under boughs and leaves to get a nearer shot at game. Practically, however, it is often hard to say for which of these two purposes a particular colour has been developed; and often the same colouring must enable the animal both to deceive its enemies and to escape the observation of its prey. We shall not, therefore, attempt in the sequel to distinguish between them.

One large class of imitative colours consists of a general resemblance to the whole surrounding environment. Of this we have cases in the soles and other flat-fish which exactly imitate the colour and speckled appearance of the sand on which they lie—so much so that even a careful human observer is often deceived at a distance of a few feet. Other instances are those of the birds, reptiles, and insects of Sahara, all of which, as Canon Tristram observes, copy closely the grey hue of the desert around them. Arctic animals are almost universally white. The fishes and crustacea which live among the sargasso weed have a general yellow tint which renders them indistinguishable from the surrounding masses of algæ. Large marine animals, as Mr. Darwin points out, have their backs dark and their bellies whitish, which exactly corresponds to the general distribution of light and shade, as a spectator looks up or down in the water. Forestine birds and reptiles have ordinarily a ground-tint of green; and small green snakes and lizards are commonly found among grass or low herbage. Geckos are marbled like the walls and rocks on which they run. Some sea-side butterflies have sand-coloured wings. Aphides and many leaf-eating caterpillars are bright green in hue. Other instances are too numerous for insertion here. It is worth notice, however, that we find the general tendency to imitative colouring, in accordance with the whole environment, most strongly displayed where the environment is most uniform in its hues—as in Sahara, the Arctic snows, the sargasso sea, or the sands of the sea-bottom; because, in such circumstances, any variation of tint would be especially noticeable. Where the general distribution of colour is most varied, as in tropical forests, we find the greatest variety of animal colours; while the imitative devices are usually far more specialised, so as to resemble some particular object in the environment, not the prevailing hue of the environment as a whole.

In a second class of cases the resemblance, though still general, shows some more specialised features than those noted above. Thus, many caterpillars have spots which mimic the distribution of light and shade among the leaves on which they feed; and Sir John Lubbock refers to a like cause the colouration of those great cats which, like the leopard and jaguar, live among trees.[1] Similarly, the same naturalist points out that the large grass-frequenting caterpillars have longitudinal lines, corresponding with those of the herbage around; while "those which live on large-veined leaves have oblique lines, like the oblique ribs of the leaves." The jungle cats, too, such as the tiger, have perpendicular stripes, "rendering them very difficult to see among the brown grass which they frequent;" while "the ground cats, such as the lion and puma," falling, of course, under our previous class, "are brownish or sand-colour, like the open places they inhabit." Here, as before, only a few typical instances can be quoted, out of many hundreds collected by various careful observers.

A very specialised form of this adaptation to particoloured environments is found amongst those animals which, like the chameleon, and the chameleon-shrimp, possess the power of altering their colour, in accordance with the surface upon which they rest. But in this case it is remarkable, as Mr. Wallace observes, that only such colours can be produced as occur normally in the natural environment of the particular species.

A third class of cases with imitative colouring proceeds

[1] See his interesting Glasgow lecture, "On certain Relations between Plants and Insects."

from general to special resemblances. Here we may place all the leaf-insects, stick-insects, and other creatures which present close similarities to various surrounding organic bodies. A sufficient number of these have been already mentioned to avoid the necessity for repetition at present.

A special case of this third class is shown in the well-known phenomena of *mimicry*, with which Mr. Bates and Mr. Wallace have made us familiar. These, too, have before received ample attention, and need not longer detain us now. With them we may close our first division of Imitative Colours.

The second division, that of Prohibitive Colours, embraces those cases where a colour acts as a warning of some noxious or disagreeable quality in its possessor. These colours are usually very conspicuous, as it must be supposed that they court attention, and so prove protective to the species. Among them may be noticed the bright-coloured but nauseous caterpillars and butterflies, numerous inedible reptiles and amphibia (such as Mr. Belt's Nicaraguan frog already quoted), several birds of pugnacious habits, and perhaps some beetles and dragon-flies. Mr. E. N. Moseley believes that the colour of many marine organisms are prohibitive, and act as warnings to hungry passers-by. For my own part, however, I must confess that, when I consider the universality of colour as a means of attraction, I am almost as much inclined to doubt the reality of these explanations as Mr. Wallace is inclined to doubt the reality of sexual selection.

To sum up, we may conclude that the whole colouration of the organic world is, in the rough, perfectly explicable upon the hypothesis that the higher animals generally possess a colour-sense essentially identical with our own; while it is absolutely inexplicable if we suppose that they do not possess such a colour-sense. The inference is almost irresistible, that this hypothesis is true. Our cumulative proof has now been completed. We have seen that flowers, fruits, insects, birds, and mammals, all show us just the colouration which we should naturally expect if we believed all the more developed animals to see colours as we see them. We have also observed that many of them do undoubtedly possess such powers in a manner essentially similar to ourselves. Our hypothesis is thus a hypothesis which explains all the facts; the cause which it postulates is a *vera causa*, a cause otherwise known to be real and sufficient for the production of the facts; and so far as many of the cases are concerned, it is not a hypothesis at all, but a known and ascertained certainty. The grounds for believing in a common and identical colour-sense amongst all the higher animals are accordingly seen to be practically irresistible.

Note.—At the conclusion of the present portion of my work which deals with the colour-sense in lower animals, it may be well to point out what are the chief instances of organic colouration which the theories here adopted leave yet unexplained. They may be briefly summed up under three heads. The first includes the radiate animals, and such other marine creatures as the sea-slugs and some of the lower articulates. It is possible that the colours in these cases may be purely adventitious, depending entirely, like the green of leaves, on the chemical constitution of the pigmentary substance, and subserving no special function as colours. This is particularly likely in the case of deep-sea organisms, living at a depth where little or no light can ever penetrate. (See Sir Wyville Thomson's "Depths of the Sea," *passim*, and especially pp. 465, 466.) Nevertheless, animals found under such circumstances occasionally possess very large and striking eyes (see, for example, the figure of *Cystosoma Neptuni* in Sir W. Thomson's "Voyage of the *Challenger*," p. 130), so that the colours may perhaps be protective. Upon this difficult subject the reader may consult Mr. Moseley's interesting papers, where the colours of deep-sea organisms are explained as survivals of a habit originally acquired for protective purposes in shoal water. The second class includes the shells of mollusca. At present, I see no other explanation of their colours save that they are purely adventitious; but this last refuge must only be regarded as provisional, since fresh facts or suggestions are continually coming to light, which enable us to discover some functional reason for what at first sight appeared purely accidental. The third class includes the eggs of birds. And here I am disposed to allege as a possible explanation that the colouration may act as a supplementary allurement to the instinct of incubation, just as sexual colours act as a supplementary allurement to the instinct of reproduction. This theory will seem less far-fetched when we recollect the fact that the eggs of reptiles, usually abandoned by the mother, are generally quite dingy in their coverings, while those of birds, forming objects of such great parental solicitude, are almost always more or less beautiful in their hues. And if we put these indications beside the other marks of æsthetic feeling in birds—their song, colour, dermal adjuncts, ornamental nests, bowers, and occasional habit of abstracting brilliant objects—the theory certainly gains in verisimilitude. On the other hand, it must always be remembered that the occurrence of colour never really demands an explanation in organic bodies, any more than it does in the ruby, the sapphire, or the emerald.

For further details upon the colouration of animals the reader must be referred to Mr. Wallace's admirable work on "Tropical Nature."

CHAPTER XI.

THE COLOUR-SENSE IN MAN.

We have now completed our survey of the colour-sense in animals generally, and we come to consider its manifestation in man.

If the conclusion to which we have been led in our previous investigation be correct, if all the higher animals, and amongst them the quadrumana, be endowed with a perception of colour substantially the same as our own, then it will naturally follow that man, the descendant of an advanced quadrumanous type, must have possessed the same faculty from the very earliest period of his separate history. The colour-sense must be a common property of all mankind, in every country, and in every age.

Here, however, we are confronted by the adverse theory of Mr. Gladstone and Dr. Hugo Magnus, who endeavour to convince us, on the contrary, that the sense of colour is quite a late and post-historical acquisition of the human race. From philological evidence in the Vedas, in the Hebrew scriptures, and in the Homeric poems, they conclude that some three thousand years ago the foremost tribes of the Semitic and Aryan races were incapable of distinguishing between red, blue, green, and yellow. Starting from such an imaginary primitive state, they trace up the development of the colour-sense through the succeeding ages, marking out four principal stages in the growth of the perception. All this startling theory they set forth on purely philological grounds. I shall briefly give the main points of their hypothesis, almost in the very words of Mr. Gladstone.[1]

The starting-point is an absolute blindness to colour in the primitive man. Thence, in the progressive education of the organ, three chief colours have been successively disclosed to it, and have appeared in the order of their greater or less refrangibility—red, green, violet.[2] The first stage attained is that at which the eye becomes able to distinguish between red and black. Red comes first into our perceptions, because it is the most luminous of the colours; but, says Geiger, in the *Rigveda* white and red are hardly severed. In the next stage of the development, the sense of colour becomes completely distinct from the sense of light. Both red and yellow with their shades (including orange) are now clearly discerned. To this stage Magnus refers the Homeric poems, in which red and yellow colours are set forth, while no mention is made (according to these authorities) of green or blue. The characteristic of the third stage is the recognition of colours which in point of luminousness belong to neither extreme, but are in a mean, namely, green with its varieties. Finally, in the fourth stage of the development, we find an acquaintance with blue begins to emerge. This is a stage not even now reached universally; for example, in Burma (it is alleged by Bastian) a striking confusion between blue and green is a perfectly common phenomenon, and a like confusion is not unusual among ourselves by candle light.[3]

Of course, the first point which strikes an evolutionist on being confronted with this elaborate theory is the

[1] I have to thank Mr. Gladstone for his courtesy in forwarding me a copy of his pamphlet, and also for kindly calling my attention to some controversial articles which appeared on this subject in *Kosmos*.

[2] I copy Mr. Gladstone's words, but he evidently means in the *inverse order* of their refrangibility.

[3] Extracted almost literally from Mr. Gladstone's article on "The Colour-Sense" in the "Nineteenth Century," for October 1877. References to the works of Geiger and Magnus, as also to the various controversial papers which they have called forth, will be found in full on a previous page.

utter inadequacy of the time assigned for the origin of such strong and fundamentally differentiated sensations as those of colour. Had Dr. Magnus said three million, or even thirty million years, the evolutionist could have hesitated on the score of insufficient elbow-room; but when our author suggests three thousand years for the growth of a radically separate set of sentient organs, our incredulity becomes absolute and irrevocable. It would be useless, however, to oppose the doctrine on such purely *a priori* grounds, only efficient for those who accept the general hypothesis of evolution: and we must therefore seek to discover what *a posteriori* arguments can be urged on the other side, against the philological evidence of Mr. Gladstone and Dr. Magnus.

There are two kinds of proof for the universality of the colour-sense in man which we may offer in opposition. The first method consists in showing that all human races at the present day, including the lowest savages, do actually possess just the same sense of colour as ourselves: whence we may argue with considerable probability that they derive that sense from a common ancestor, and that the Homeric Akhaians were not likely to be destitute of perceptions possessed by the Bushmen, the Australians, and the hill-tribes of India. The second method consists in showing that works of art and other remains of the early historical races or of pre-historic man yield evidence that the colour-sense was fully developed long before the epoch of the Iliad or the Book of Genesis. Both these methods of proof we shall employ here.

In order to discover what was the present state of colour-perception amongst existing savage races, I had recourse to two plans. In the first place, I consulted a large number of works by travellers and others respecting modern savages, and extracted all passages which bore upon the question at issue. And in the second place, I supplemented the information thus obtained by direct inquiries upon the subject, addressed to missionaries, government officials, and other persons working amongst the most uncivilised races. I printed a circular letter, which I forwarded to various parts of the world, requesting numbered answers to the following questions:—

"(1.) What is the race to whom your answers refer?
(2.) How many colours can they distinguish?
(3.) Can they distinguish between blue and green?
(4.) Can they distinguish between blue and violet?
(5.) Can they distinguish any mixed or intermediate shades, such as mauve, lilac, orange, and purple?
(6.) For how many colours have they names in their language?
(7.) Have they separate names for green and blue?
(8.) Have they separate names for blue and violet?
(9.) How many colours do they discriminate in the rainbow?
(10.) What pigments do they employ in personal decoration or in ornament?
(11.) Have they a separate name for each pigment?
(12.) Have they separate names for any colour for which they have no pigment?"

To these questions I received a large number of courteous answers, from Europe, Asia, Africa, America, and the Pacific Islands; and I may as well say at once that they bore out *in every case* the supposition that the colour-sense is, as a whole, absolutely identical throughout all branches of the human race. As it would be tedious, however, to print all the answers in full, as numbered, in a tabular form, I shall give the whole evidence together, remarking in each case whether my information was derived from books or from a correspondent.

I shall also premise that, lest there should be any suspicion that I myself was deficient in colour-perception, I rigorously tested my own powers with all the objective experiments I could hear of or devise, including Dr. Stilling's Tables for the Examination of the Colour-Sense, and many like careful tests. The result proved beyond doubt that my eyes were perfectly normal, and possessed at least quite the full average faculties of colour discrimination.

Probably nobody will deny that the ordinary European nations, and the Chinese, Japanese, and Hindus in Asia, have colour-perceptions identical with our own. The mere inspection of their works of art, and especially of their imitative paintings, clearly shows that they perceive and represent external objects of the same hue as ourselves. I shall therefore pass them over without further proof, and proceed to examine the various lower races, beginning with the most advanced among them, and ending with the most degraded of all.

The North American Indians, as I can testify from personal experience, make use of pigments for the three so-called primary colours, and also for green, orange, and purple. My father, Mr. J. A. Allen of Kingston, Ontario, who kindly undertook to distribute my circulars in America, thus describes some Indian art products of the unsophisticated north-western tribes. "While I write, I have before me some leggings and mocassins, made by Indians of the far west—so far off as to be hardly reached by the last outskirts of our civilisation. In these, the lines of colour are never confused—never fail to correspond, or run into one another. The leggings have ornaments in white, dark blue and pale blue, dark green and pale green, and yellow, on a scarlet ground with a black edge. There are also on the mocassins pale blue, purple, brown, green, pink, and solferino, on a buff ground, with a strip of scarlet binding. The pattern is strictly symmetrical: each colour being introduced at exactly the same angle or portion of the pattern throughout—not a confused mass of colours. They were brought . . . from the Chippewa Indians, 750 miles north-west of Kingston." Mr. P. B. Bell answers my questions with regard to the

Ojibways in similar language. They can clearly distinguish between blue and green, and also between blue and violet, though they have no distinctive name for the latter colour. They have, however, no less than seven different colour-names, including separate words for green and blue. Other correspondents mention like facts of other tribes. In all, the power of discrimination seems quite equal to our own, though the nomenclature generally extends only to the four or five most markedly different colours—a point to which we shall return in a later chapter.

The evidence with regard to the historical races of North and South America is equally strong. The ancient Mexicans were famed for their mosaic of feather work, and their subtle taste in colour is praised by several competent Spanish authorities.[1] I have satisfied myself, by personal observation of Mexican works of art, that they clearly distinguished all the colours mentioned by Mr. Gladstone. The Yucatanese "painted their bodies red,"[2] but the children whom they offered as victims to their gods were anointed blue. Stephens says that their principal colours were red, green, yellow, and blue;[3] while Catherwood praises their harmonious blending of various hues. The Chibchas, we are frequently told, had a special taste for emeralds and other green stones, which is scarcely consistent with the idea that they could not see their colour.[4] The Peruvians, according to Garcilasso, were "very fond of vermilion red;"[5] but they too had a particular fancy for turquoises, emeralds, and crystals.[6] It is specially noticed that Atahuallpa wore a collar of large emeralds. Mr. Clements R. Markham informs me that

[1] Clavigero, vii. 48, 57, *et alii alibi.* See also Helps, iv. 69. In this and many other cases I have availed myself of the large and careful collection of instances in Mr. Herbert Spencer's "Descriptive Sociology," which, however, I have greatly supplemented, when possible, from other sources, or from direct inspection of remains.

[2] Landa, Relacion, § 20.

[3] Yucatan, vol. i., p. 205.

[4] P. Simon, p. 256; Uricoechea, p. 52; Piedrahita, v. 4, &c.

[5] Garcilasso, viii. 25.

[6] Ibid., viii. 23.

the Peruvian language had separate words for green and blue; and in one of his published works he mentions that the people "knew the secret of fixing the dyes of all colours,—flesh-colour, yellow, grey, blue, green, black."[1] Their pottery also receives high commendation as "remarkable for harmony of colour." So that, on the whole, we may credit all the semi-civilised American races, not only with a proper colour-sense, but also with considerable artistic sensibility.

Even of the wretched Fuegians I find it noticed that red is their favourite colour,[2] and that they paint their faces with red, black, or white.

Passing over to Africa, we meet with evidence of a similar sort. The Rev. A. R. M. Wilshere of Robbins Island, Cape of Good Hope, obligingly answered my questions with regard to four South African tribes, Korannas, Hottentots, Makatese, and Mozambiques. In every case, he found by personal inquiry that all recognised colours were discriminated in just the same manner as by Europeans. Every one of these tribes can distinguish between blue and green, as well as between blue and violet; and they possess names for six separate colours, including green and blue, but not violet; yet as they can *see* the latter colour, the deficiency here is simply one of nomenclature. In one case, a Mozambique had no native word for purple, which is wanting in his own language, but had learnt the name in Dutch, and applied it correctly. Mr. Wilshere is of opinion that the Africans he examined could discriminate just as many colours in the rainbow as he could himself.

A lady, whose name I have no authority to publish, gives me a very clear account of the Bushmen, derived from immediate inquiry, and marked by a careful and conscientious accuracy which could not sufficiently be indicated without transcribing her letter in full. The

[1] Markham's Cieza, p. 405.

[2] Fitzroy, Voyage of the *Adventure* and the *Beagle*, vol. ii. p. 177.

members of this race can undoubtedly distinguish red, yellow, green, blue, violet, purple, and orange. Their colour vocabulary is unusually full; for besides names for the common primaries, "there are also various compound names, where the names of two colours are used together; as well as further names for at least five (and probably more) shades of colour;—for instance, for light purple, for lavender and grey, for stone-colour, for brownish green, and for blue green." At a meeting of the Royal Society of Edinburgh, in January 1878, Bishop Cotterell, formerly of Grahamstown, gave a similar account of this race, whose colour-perception he believed to be quite as acute as our own. Some of their paintings, which have been exhibited in this country, fully bear out the truth of both statements.

With regard to the common negro types, my own observations made upon West Coast Africans in Jamaica (not born in the West Indies, but taken from Africa direct), convinced me that they could perfectly discriminate all colours as well as myself. The ordinary negro women possess the same abundant vocabulary, as regards the colours used in dress, which distinguishes their sex in Europe. Nevertheless, to make assurance doubly sure, I append a few references to their pigments and works of art in a native state. The Congo people paint themselves with red ochre,[1] and the Mandingoes dye cloth blue with indigo. The huts on the lower Niger are stained blue and white.[2] The inland negroes dye their hair bright blue. Indeed, throughout all Central, Western, and Northern Africa, where indigo exists, it appears to form a favourite pigment. The Ashantis use red, blue, yellow, and green.[3] The Bushmen paint themselves with red ochre,[4] while among the favourite beads of the Bechu-

[1] Tuckey, Expedition to the Zaire, p. 103.

[2] Allen and Thomson, vol. i. p. 320.

[3] Beecham, Ashanti and Gold Coast, p. 147.

[4] Barrow, i. 288.

anas, Burchell mentions light blue.[1] Other instances might be adduced by the dozen; but it will be better simply to refer the reader to Mr. Spencer's great collection, or to any manufacturer of trading beads.

The Rev. F. A. Gregory of Antananarivo informs me that the Malagasy people distinguish accurately between all colours, and have separate names for no less than thirteen hues.

Among the hill tribes of India, colour-perception seems to exist in exactly similar perfection. Mr. Adarji Jivanji, Deputy-Collector at Maldha, answers my questions with regard to the Chondras, Gámtas, Dublas, and Bhils. These aborigines can certainly distinguish between blue, green, and violet, though not possessing separate names for each. Other observers return similar answers for the Nágás, Gonds, and like lowest races. In every case, discrimination seems perfect, vocabulary only being at fault. My friend, Dr. W. W. Hunter, Director-General of Statistics for India, in his "Comparative Dictionary of the Languages of India and High Asia," gives the words for green, red, and black in 107 Non-Aryan dialects, including those of the Todas, Khonds, Uráons, Kols, Gonds, Santáls, Nágás, Garos, and other low-type aborigines.[2] There is also abundant practical evidence that these races discriminate blue, which, according to Mr. Gladstone and Dr. Magnus, represents the highest stage of colour-perception. The Kukis dye cloth with indigo.[3] The Nágás wear blue kilts,[4] and cotton dyed with indigo, as well as white cloth, with red and blue fringes.[5] The Todas embroider their mantles with blue thread.[6] The Santáls use strips of red, blue, and yellow cloth. The Karen-

[1] Southern Africa, vol. ii. p. 569.

[2] My thanks are due to Dr. Hunter for kindly forwarding my circular letters to various Indian civil servants, amongst the least civilised tribes, and also for kindly permitting me to use for reference his valuable library of works relating to India.

[3] Stewart, in Journal of the Asiatic Society of Bengal, vol. xxiv. p. 636.

[4] Grange, Ibid., viii. p. 469.

[5] Ibid., p. 613.

[6] King, Journal of the Anthropological Society, July 1870, p. 23.

nees of Burma wear red and blue clothing.[1] Here, again, only the necessary limit of space prevents the multiplication of instances, but many hundreds could be given if required, to exactly the same effect.

With regard to the Pacific Islanders, my fullest information comes from the Rev. S. J. Whitmee, a missionary in Samoa, whose name is already well known to philologists and students of folk-lore, as that of a careful and strictly scientific observer. Mr. Whitmee considers that the Samoans can "distinguish all the prismatic colours, and many of the mixed shades." They have separate names for blue and green, and others for the minor modifications of these hues. They have also a separate name for violet. They discriminate such intermediate or mixed colours as mauve, lilac, orange, and purple; they use distinct terms for varieties of red (crimson and brick red); and they have a name for chocolate-brown. On the whole, their nomenclature seems somewhat awkward and confused, but their perception perfect: and as to taste, "they like bright colours," says Mr. Whitmee, "such as mauve, bright blue, purple, magenta, &c.; but they do not mix these in a grotesque manner in their dress to any great extent. . . . Large showy patterns in prints, &c., they will not look at. Bright red is not used to any great extent, and yellow is not at all in favour." The Hawaiians are equally discriminative of colour distinctions, and one whom I had the opportunity of questioning showed quite as acute sensibility as any European. Mrs. Bird mentions dresses of pure white, crimson, yellow, orange, scarlet, blue, or light green as worn by the women;[2] and throughout her book she bears constant testimony to the universal feeling for colour harmony. I specially note that she mentions the use of green for decorative purposes in embroidery.[3] Lord G. Campbell remarks that the Admiralty Islanders who came

[1] Fytche, Burma Past and Present. i. 337.

[2] Hawaiian Archipelago, p. 21.

[3] Ibid., p. 160.

on board the *Challenger* to be painted were equally pleased with daubs of red or of green pigment.[1] In New Guinea, blue lines are employed for tattooing,[2] and the natives paint their bodies with red, yellow, and black.[3] The petticoats worn by the women on gala days are dyed red and green, with intermediate bands of straw-colour. The New Zealanders stain themselves with red ochre; but I find ear-drops of green jade mentioned among their favourite ornaments.[4] Their blue tattoo marks are too well known to require special mention. As regards the Malay Archipelago generally, Mr. Wallace's vocabularies contain words for black, white, red, and blue in thirty-three Malayan languages. Mr. W. Gifford Palgrave mentions white, yellow, red, green, and blue among the dyes used by the Philippine Islanders.[5] For Australia, I find in a vocabulary of the Wailwun language separate words for black, red, yellow, green, and brown,[6] and several accompanying lists of other dialects, collected by different authorities, show similar results. I may add that whenever I have had the opportunity of consulting intelligent travellers upon this subject, they have always at once given their opinion that the savages with whom they were conversant distinguished all colours perfectly.

Finally, even the wretched Andaman Islanders, probably the lowest known specimens of the human race, daub their faces with red and white.[7]

Such are a few selected instances from the mass of evidence which might be adduced in favour of the belief that all existing races possess a fully-developed colour-sense. I think they will probably suffice to show the general truth of our proposition. And if savages so low

[1] Log-Letters from the *Challenger*, p. 282.

[2] Voyage of the *Rattlesnake*, p. 262.

[3] Earl's Papuans, p. 26.

[4] Anga's Australia and New Zealand, vol. i. p. 327.

[5] Malay Life in the Philippines, "Cornhill Magazine," Aug. 1878, p. 157.

[6] Journal of the Anthropological Institute, vol. vii. No. 3, p. 246.

[7] St. John, "Transactions of the Ethnological Society, New Series, v. 45. See also Colebrooke in "Asiatic Researches," iv. 390.

as some of these actually enjoy such high powers of discrimination, can we consistently deny the like to the early Hebrews and Akhaians? I have not so high an opinion as Mr. Gladstone of the rude Homeric warriors or the fierce conquerors of Lower Syria, but at least I cannot believe that they were less advanced in simple sensuous perceptions than the naked Todas or the wild half-human Andamanese.

And now let us go on to inquire whether we cannot find abundant proofs of a highly evolved colour-sense long before the period to which the criticisms of Geiger and Magnus refer.

First, in our backward view we will take the case of Nineveh. Of the enamelled bricks dug up in this city Sir A. H. Layard says, "The colors (*sic*) have faded, but were probably once as bright as the enamels of Khorsabad. The outlines are white, and the ground a pale blue and olive green. The only other color used is a dull yellow."[1] In many of these cases blue figures occur on a green ground, which clearly shows that the two colours were accurately discriminated. The pigments consist of an antimoniate of lead for the yellow; an oxide of tin for the white; a copper for the blue; and a sub-oxide of copper for the red. Of Babylonian bricks the same authority observes, "The principal colours are a brilliant blue, red, a deep yellow, white, and black."[2] The Rev. A. H. Sayce, the distinguished Assyriologist, writes to me as follows:—"The Assyrian language seems to have had no word for 'green.' Sometimes 'green' is represented by *arku*, 'yellow,' but more commonly by *'samu* or *'sihmu* 'blue' (like the Welsh *glas*). But the enamelled bricks show that both the colours blue and green were known and used." An inspection of the existing remains in the

[1] Nineveh and Babylon, p. 166.

[2] For an account of Babylonian colours, see Rawlinson's "Ancient Monarchies," iii. pp. 406, 407, and Layard's "Nineveh and Babylon," pp. 507, 672.

Louvre and the British Museum will sufficiently prove to the most sceptical that the colour-sense of the Egyptians was essentially identical with our own.

As to the Egyptians proof seems almost unnecessary; yet, for the sake of formality, it must be given. 'Their colours,' says Sir Gardner Wilkinson, 'were principally blue, red, green, black, yellow, and white. The red was an earthy bole; the yellow an iron ochre; the green was a mixture of a little ochre with a pulverised glass made by vitrifying the oxides of copper and iron with sand and soda; the blue was a glass of like composition *without the oxide of iron*; the black was a bone or ivory black; and the white a very pure chalk.'[1] Here the works which I have examined clearly prove that the difference between blue and green was perfectly perceived, and that pigments were specially prepared to show the two colours. Again, Sir Gardner observes, 'With the Egyptians the favourite combination of colour was red, blue, and green; when black was introduced, yellow was added to harmonise with it.' Nor is this all; for though they had few mixed colours, yet 'purple, pink, orange, and brown are met with.' A modern author, speaking of their ceramic art, uses language of even a more decided kind. 'One finds in the rich series of the Louvre,' says Jacquemart, 'pieces with white glaze, heightened with patterns engraved or painted in black, blue, dark violet, green, and even red; the green and the copper blue blend with cobalt blue, black, brown, violet of manganese, white, and yellow. What proves, besides, with what certainty the potters operated these combinations is that we meet with Egyptian porcelains where the diverse tints occupy very confined spaces, and contrast strongly the one with the other; a blue statuette has the face coloured with golden yellow; dark blue bracelets bear upon their surface hieroglyphics in sky blue, or *vice versa*.'[2] Here,

[1] Ancient Egyptians, ii. [illegible]

[2] History of the Ceramic Art, English translation, p. [illegible]

then, is complete science, consummate experience, and precision of execution."

But a few hours spent at the British Museum, especially amongst the mummy-cases, will do more to convince the reader of the Egyptian colour-sense than pages of quotation. Among the wall-paintings, too, I would call particular attention to those numbered 170, 177, 180, 181, and many neighbouring specimens of the eighteenth and nineteenth dynasties.

As regards the date of these coloured remains, I made inquiries of Dr. Birch, who kindly informed me that the system of colouring culminated under the two dynasties abovementioned, and grew gradually debased thenceforward. Accordingly, the finest specimens of Egyptian colouration are far anterior to the earliest conjectural date ever proposed for the Homeric poems.

Can we go still further back, to the prehistoric age, and show by the evidence of existing remains that even then man possessed a developed colour-perception? I believe that we can, to some slight extent at least.

Of course, in dealing with the art-products of the most primitive period, we must not expect to find such unmistakable proofs as those of pigments and paintings which we meet with in Egypt and Assyria. If the savage races of the present day were to die out and leave no traces but those of their scanty implements, we could hardly hope to discover many marks of their now undeniable use of colour. The tattooing, the body-paints, the strips of coloured cloth, the flowers and feathers, all would be lost by decay. Even the rude decorations of the pottery would probably fade by long exposure to earth, rain, and air. The only remains which could convey to us some faint idea of that love for colour which distinguishes the real savage would be the few permanently-coloured implements of stone or metal. I was standing with a friend one day by the glass cases in the Oxford Museum which contain the modern savage utensils, when he called my attention to a stone hatchet (I think from the Admiralty Islands), bound to its wooden handle by a coil of red and yellow cord, arranged so as to form a pretty pattern. We had been talking upon this very subject, and he rightly pointed out at once that if the hatchet were buried in the earth for a very short period, the red and yellow cord would decay, and no mark of the original æsthetic intention would be left. Similarly, if we did not learn from the actual words of Cæsar, and the constant allusions of the Roman poets, that the ancient Welsh stained their bodies blue, we should know almost nothing about their sense of colour. The conditions under which we find prehistoric remains—buried in barrows, covered up in alluvium, sunk in lakes, or hidden in the damp floor of caves—necessarily preclude the possibility of obtaining any very definite information on this head. Still the evidence, such as it is, distinctly favours the belief in a normal colour-sense amongst these most primitive men.

To begin with the highest stratum of the prehistoric period, we may put in the evidence of Dr. Schliemann, who gives plates of red and yellow Mycenean pottery, with colours distinctly brilliant and fairly well demarcated.[1] It is true, no greens or blues appear upon these vessels, but the reason for this, as we shall hereafter see, was much more probably due to the lack of a proper pigment than to a deficiency of the colour-sense. Among the gems of Mycenæ, agate, porphyry, and greenstone occur, and we can hardly doubt that their colour was their chief recommendation in the eyes of the early chieftains in whose graves they are discovered. Amber and lapis lazuli are also found, showing a probable knowledge of yellow and blue. Indeed, the mere fact that gold and silver vessels are used, proves a certain amount of colour perception, for gold only differs from silver in its colour,

[1] Mycenæ and Tiryns, plates A, B, C, and D. See also "Troy and its Remains," p. 49.

and could not be discriminated in any other way, except by chemical tests.

But that some at least of the Bronze Age savages possessed a taste for blue, and employed it in their arts, is conclusively shown by a bracelet from the Swiss lake dwellings, which has a red ground, distinctly and prettily enamelled with yellow and blue bands in a regular pattern.[1] Blue and white glass beads also form part of the treasure recovered from the *débris* of these primæval villages.[2]

Going back to the Stone Age, we find similar evidence, though of a scanty sort. "Stones remarkable either for their colour or shape," says Dr. Evans, "appear at all times to have attracted the attention of mankind, and frequently to have served as personal ornaments."[3] Among the ordinary materials of stone weapons Damour mentions, "quartz, agate, flint, jasper, obsidian, fibrolite, jade, chloromelanite, amphibolite, aphanite, diorite, saussurite, and staurotide;" and we can hardly fail to notice that many of these minerals are remarkable for their beauty of colour. "In the Christy collection," says Dr. Evans elsewhere, "is a *bola* formed of a polished spherical red stone, mounted in such a manner as to show a considerable portion of its surface, which has evidently been regarded as too handsome to be entirely concealed by the leather."[4] Canon Greenwell found beads of bluish-green glass in barrows in Wiltshire.[5] Amber was also found in similar situations; and beads of rose-quartz, belonging to the Stone Age, are recorded at Argenteuil.[6] Pebbles, selected apparently for their beauty, are constant accompaniments of the dead, some of them being described as "sea-green," "pink," and "red."[7] How far back in time these

[1] Desor and Favre, Le Bel Age du Bronze Lacustre en Suisse, p. 23, and plate iii. fig. 15.

[2] Ibid., p. 15, and plate iii. fig. 1.

[3] Ancient Stone Implements of Great Britain, p. 422.

[4] Ibid., p. 378.

[5] British Barrows, p. 55.

[6] Evans, *ubi supra*, p. 413.

[7] Ibid., p. 419.

deposits may reach I cannot say; but in one case at least, that of the Dardanelles remains, I find it distinctly stated that they are of palæolithic age, "and the most common material is red or other coloured jasper."[1] The Christy collection also includes axes from Barbadoes of "green-stone, mottled jade, green jasper, and a hard light green slate."[2] I may add that the stone implements in Dr. Schliemann's Trojan collection at South Kensington from all depths, though much begrimed by age, show traces of deep colour in many different shades. The most conclusive of all proofs, however, is the occurrence of ochre in barrows.[3] And Dr. Rollestone informs me that he has constantly found lumps of ruddle, doubtless for personal ornamentation, laid by the side of the dead. He thinks the general character of prehistoric remains can leave no doubt on the mind of an expert that primitive man possessed a considerable perception of colour.

Few and inconclusive as these facts undoubtedly are, they yet afford a reasonable presumption in favour of a colour-sense in the earliest members of the human race. However, it will not be necessary to base any part of our argument, as against Mr. Gladstone and Dr. Magnus, upon so insecure a foundation. We may rest content with the cases of the Egyptians and the modern savages, having the post-historic theory here on the horns of a dilemma which it cannot easily escape. If, on the one hand, we put forward only the case of Egypt, it might be answered that the development of a colour-sense is a question of relative culture, not of mere chronological order; and if, on the other hand, we put forward only the case of modern savages, it might be answered that the development of a colour-sense is a question of chronological order, not of relative culture; but if we put forward the two cases together, it will hardly be possible for any one to shirk

[1] Wilson, Prehistoric Man, vol. i. p. 111.

[2] Ibid., vol. i. p. 123.

[3] Greenwell, British Barrows, p. 113.

the first difficulty by answering us in one way, and then to shirk the second difficulty by answering us in the other.

When we examine the extraneous arguments by which the theory is supported, we find they have very little real weight. Thus it has been suggested that colour-blindness may be a survival from this earliest type of vision; but when we look a little deeper into the question we recollect that the commonest form of colour-blindness is that which cannot discriminate red from green—whereas red ought, according to the theory, to be the most universally discriminable of all—while it is yet quite able to discriminate green from blue. Furthermore, there is good reason for believing that colour-blindness is far commoner in civilised communities than amongst savage tribes. According to M. Favre, no less than 3,000,000 persons in France are afflicted with this defect, while Stilling places the proportion in Western Europe generally at 5 per cent.[1] On the other hand, the abnormality appears to be infrequent or unknown amongst the lower races; so that it must be regarded rather as a disease of civilisation than as a survival from the primitive state. Again, Dr. Magnus[2] quotes Geiger's remarks about the dog and the flower to prove that quantitative consciousness of intensity has nothing to do with qualitative consciousness of kind; or, as Mr. Gladstone puts it,[3] "that the dog, with his wonderful faculty of scent, has no power of distinction between smells which are agreeable and smells which are offensive." Really, as we have already seen, there is no reason under the sun why a dog should find the smell of flowers affect him distinctively in any way; while if we set him to track a scent, crossed and recrossed from step to step by a hundred varying trails, we shall see that he does possess a qualitative sensibility of the very highest order. Accordingly the supposed analogy breaks down immediately.

[1] Stilling, Prüfung des Farbensinnes, p. 5.

[2] Geschichtliche Entwickelung des Farbensinnes, p. 3.

[3] The Colour-Sense, p. 3.

Or, once more, to take a third instance, Mr. Gladstone speaks of the difficulty experienced in distinguishing blue from green by candle-light as a trace of the undifferentiated stage; but really violet is quite easily discriminated under such circumstances, while it ought, if the theory be true, to be the least discriminable of all colours; and as to the confusion itself, it is in fact objective, not subjective, depending upon the peculiar constitution of certain lights which do not contain all the prismatic colours in the normal proportions of sunlight. One might almost as well argue that as blue Bengal fires make everything look blue, therefore blue is probably the original colour discriminated by the eye.

Indeed, the whole hypothesis has only one weak set of facts to support it, namely, the supposed testimony of language. Setting aside for the present the possibility that this testimony has been misinterpreted (which I hope to show in the sequel), it must at least be granted that the negative evidence of language by itself forms the most untrustworthy ground for such a superstructure, especially if contradicted by other positive proofs. I look in vain through the pages of Geiger, of Magnus, and of Mr. Gladstone, for any indication that pictures, sculpture, pottery, or other art products have been taken into consideration at all. Every one of these students seems to have sat down in his library, consulting the frail linguistic authority of the Vedas, the Homeric poems, and the Hebrew prophets; but never to have tested the truth of the philological conclusion by reference to museums and art collections, or even to the works of antiquaries and explorers. Dr. Magnus argues *a priori* as to what the sensations of the savage *must be* like; but he has taken no pains to inform himself, either by observation, inquiry, or reading, what they actually *are* like. I cannot help believing that a little more care and a little more extended search would have led him to abandon his theory, based as it is upon the shifting sands of half-forgotten languages. It may

CHAPTER XII.

THE ÆSTHETIC VALUE OF COLOUR.

WE have seen already that pleasure results from the unimpeded activity of a fully-nurtured structure, in immediate connection with a sentient centre, when not excessive in amount, nor surpassing the limits of easy repair.[1] Æsthetic pleasure results from such activity when directed upon objects remote from actual life-preserving function.[2]

Accordingly, the æsthetic pleasure of colour is the pleasure felt in its immediate apprehension by the mind, apart from any idea of advantage to be gained, as, for instance, from the acquisition of food. Even the lower animals show some signs of a love of colour for its own sake, as in the oft-quoted cases of the bower-birds and many monkeys. More often, however, their appreciation of colour is bound up with the essential acts of feeding and reproduction, exhibiting itself only in its secondary effects by the genesis of flowers, fruits, and bright-hued mates. But in man the æsthetic pleasure in colour becomes strongly marked, being found amongst the very lowest savages, and entering into every department of industry amongst the civilised races. From the red ochre and brilliant feathers of the naked Andamanese, up to the paintings and decorations of European palaces, we can trace its gradual development from stage to stage, becoming more and more divorced from life-serving function with every onward step, until at last the æsthetic senti-

[1] See chap. viii., *ante.*
[2] See my "Physiological Æsthetics," chap. iii. and *passim.*

animals seem instinctively drawn by the glow of fire; and though they will not approach it too closely, they show decided signs of interest in its bright glare. This same feeling reappears in the savage love for torchlight dances, for bonfires, and for like rude pyrotechnic displays; while it reaches its culminating point in fire-works, in illuminations, in Guy Fawkes celebrations, and in similar civilised exhibitions of coarse visual stimulation. In every case we feel at once that the æsthetic pleasure involved belongs to the very lowest stratum of its class, the stratum which we Europeans share in the greatest degree with the savage members of our race. Children and uncultured adults delight in the rude shocks of a fire-work exhibition, but sensitive eyes and minds shrink from the excessive demand upon optic nerve and brain.

Reflected glitter or lustre ranks next in æsthetic order among the visual stimulants. It still exercises the whole sentient organ, but not with such violence as the preceding class.[1] Amongst animals, the taste for glitter is shown by the attraction of fish towards a spoon or other bright substance, by the magpie love for secreting diamonds and jewellery generally, and by the common practice of drawing down larks to the reflected light of a mirror. The objects collected by the bower-birds are often lustrous, such as shells and smooth pebbles. The more beautiful animals also show a great tendency towards iridescence or metallic tints, which, though they contain a large element of pure colours, include likewise a great deal of mere direct reflexion. Cases in point are found among beetles, butterflies, humming-birds, sun-birds, and lizards. Glossiness frequently occurs, apparently as a sexual device, in the fur of mammals. Amongst mankind,

[1] It may be noticed in passing that our enjoyment of fire-works, bonfires, glow-worms, and fire-flies, is mainly confined to the night, when we can recuperate our powers of vision during the intervals of darkness; while our admiration of the milder brilliancy of gems and crystals belongs to the day-time, and the recuperative interval is gained by glancing rapidly at other objects.

skulls for drinking goblets, and like artistic utensils, invariably receive a glossy surface. Glass and the art of glazing pottery yield proofs of the same universal taste. Lastly, the inventions of lacquer, varnish, boot-blacking, and other artificial means for imparting lustre to naturally dull surfaces, derive their origin from a similar source.

But among all the lustrous objects which attract the nascent æsthetic faculty of primitive man, none are more important in their final effects than metals. Leaving out of consideration as too remote from our present subject the numberless uses of copper, bronze, tin, iron, and steel, it will be enough if we glance briefly at the employment of silver and gold. These had at first no other recommendation than their immediate beauty, and they were collected for the manufacture of goblets, masks, torques, beads, earrings, and articles of personal adornment. But in the course of time they became utilised as a medium of exchange, owing both to the general request in which they were held, and to the ease with which they could be divided and reunited. Hence at the present day mankind still carries on its commerce by bartering goods against the very self-same bits of shiny white or yellow metal which once hung round the naked necks of African, American, and prehistoric chieftains.

Passing on from the general stimulation of the total light-beam, direct or reflected, to the partial stimulation of its various components—the analytic colours—we have next to inquire, Has any one colour a decided æsthetic superiority over any other? The answer must distinctly be, Yes. The red and orange end of the spectrum is decidedly the most pleasurable: while the central colours, green and blue, are decidedly the least so.[1]

Many separate reasons conduce to this effect. In the first place, we have already seen that greens and blues are

[1] I have discovered experimentally that infants respond to the stimulation of light before they respond to that of colour; and that amongst colours, red is the first to attract their attention.

by far the commonest colours in nature, being those of the whole grass-clad fields, forest stretches, and wide ocean below, and also of the great open sky overhead. On the other hand, red and orange are by far the most unusual hues, being, practically speaking, unknown in the ordinary inorganic environment, and only found in a few minor parts of animal or vegetal organisms. Hence the structures in our eyes which are percipient of red, are far less frequently exercised than those which are percipient of green and blue.[1] So it will follow that they are generally in that highly unstable and fully-nurtured state in which they are capable of pleasurable stimulation. The structures for the perception of green and blue, on the contrary, being habitually stimulated to the proper extent, do not yield any specially agreeable feelings under ordinary circumstances.

Again, the luminous intensity of red, orange, and yellow is considerably greater than that of green, blue, and violet. Hence their stimulating powers may be plausibly considered as greater than those of the less luminous colours. I am glad to be able to state that I owe this suggestion to Dr. Magnus and Mr. Gladstone. It is, doubtless, to their higher luminous qualities that the red and orange rays owe that pungency and strength which is one of their distinguishing characteristics. They may be considered to approach nearest in this respect to the brilliancy of direct total light.

[1] Some of the critics who kindly noticed my work on "Physiological Æsthetics," seem to have supposed that the truth of this result would depend upon our acceptance of Young's theory of colour-perception, with which it was there affiliated. Such, however, is not necessarily the case. Whatever may be the ultimate mechanism of the nerve terminals for the reception of colour-stimulation (see an able paper by Mr. G. Stanley Hall, in the "Proceedings of the American Academy of Arts and Sciences," vol. xiii. p. 402, of which I have given an abstract in "Mind," for January 1879), it must at least be allowed that the centres percipient of red cannot be the same as the centres percipient of green and blue. Accordingly, they must be usually in a comparatively high state of nutrition, fitted for the production of pleasurable sensations. In fact, the conclusion rests upon the general conditions of sensibility, and is quite independent of any particular theory of vision.

But above either of these causes we may place, I think, the hereditary tendency of the human eye, derived from our early frugivorous ancestors. Red, orange, and yellow are the common hues by which fruits may be distinguished from the surrounding masses of green foliage. Accordingly, the eyes of frugivorous animals must be continually on the alert for such colours; and the organs for their perception, besides being immediately strengthened, must also gain numerous connections with other nervous centres, which will permit the escape of comparatively voluminous emotional waves. I do not mean that these colours will come to be intellectually associated with the pursuit of food, for although such is doubtless the case, that fact would not in itself suffice to account for the pleasure aroused; but I mean that the increased calibre of the nervous organs thus exercised, and the number of additional channels thus provided for the overflowing nervous energy, would conspire to produce a direct and immediate sensuous pleasure. This pleasure would result from the mere act of perceiving red, not from the mediate recognition of red as a symbol of food.

From the combination of these three causes, it happens that the sensation of red or orange is the most agreeable of all the pure colour-perceptions. And as the earliest and least æsthetically developed races pay attention only to the strongest stimulants, leaving out of consideration the more delicate, we may say roughly that amongst all savage tribes red is *par excellence*, and above all others *the* decorative colour. Dr. Magnus has noted this fact, and uses it as an argument in favour of his theory that red formed the first part of the visible spectrum to be separately cognised by the human eye. Mr. Gladstone speaks of "the prominence which that colour acquired both in the initial stages of the painter's art, and in the costumes of high personages. It had, as it were, got a start, and had the first possession of the ground, which, in costume particularly, it has retained. But," continues the author, and here I am pleased that I can thoroughly agree with him, "we must remember that, in public exhibition and ceremonial, it is, from its luminous character, highly satisfactory to the eye." Of course, we must further remember that red forms the favourite colour, not only of primitive man and of modern savages, but also of the young and the coarse-natured among our European nations. The Central African is bribed with yards of red calico; the West Indian negress adorns herself in a red turban; the baby in its cradle jumps at a bunch of red rags; the London servant-maid trims her cap with scarlet ribbons, and admires the soldier's coat as the most beautiful of human costumes.

But there exists yet another and more mechanical reason why red came early into favour for decorative purposes. Of all primitive pigments, by far the commonest and easiest to obtain are ochreous earths. Blue dye can only be extracted in an early culture from certain vegetal substances, which require comparatively advanced skill for their production; while greens are chiefly obtained from minerals of rare occurrence. But red earths may be found almost everywhere, and the method of their application is as simple as the ruddling of sheep. Hence we find traces of the use of ochre where scarcely any other pigments are known. Lumps of red clay lie beside the prehistoric dead in their rude barrows; and red stains for the body compose the chief decoration of modern savages. Almost everywhere that we find mention of red pigment amongst uncivilised races, inquiry shows that ochre is the material from which it is obtained. Thus the New Zealanders paint their skins red—with ochre; the Bushmen in like manner redden their bodies—with ochre; the people of the Congo do the same—with ochre. Of the Australians, the Tasmanians, the Fuegians, the Tannese, the Andaman Islanders, I see it similarly mentioned that they employ ochre for their personal decoration. So, too, in higher arts, the red and yellow of the Trojan and Mycenean pottery are clay colours. The Egyptian red, as we have already seen, was "an earthy bole," and the yellow "an iron ochre." Even among ourselves ruddle still performs many useful functions, and ranks as the simplest and easiest means of making distinguishing marks on animals, sacks, and other rural objects.

Occasionally the origin of the red pigment is slightly different. The Samoans, I learn from Mr. Whitmee, use a volcanic earth for this purpose; the Assyrian red, according to Sir A. Layard, was a sub-oxide of copper; and Mr. E. S. Morse records the discovery, in prehistoric shell-heaps at Omori in Japan, of pottery coloured crimson with cinnabar.[1] But whatever the material employed, we always see that the red end of the spectrum possessed and still possesses peculiar attractions for undeveloped æsthetic tastes.

Besides the employment of red for æsthetic purposes in the shape of pigment, we may also note its use in other shapes. For example, there is the case of the red pebbles and the pretty polished *bola* mentioned above.[2] The Mexicans used orange feathers for many decorative appliances; and the well-known cloaks of the Hawaiian kings were composed of the beautiful plumage of *Melithreptes pacifica* (note the name—as might be expected, a honey-feeder). The crimson hibiscus is a favourite flower amongst the West Indian negroes, whose huts may generally be descried at some distance by means of its massive blossoms. And I find the same brilliant flower twice mentioned by Lord George Campbell as a decoration of the person, once in the case of a girl at Kandavu, Fiji, and again in the wigs of the savage Papuans at Humboldt Bay.[3]

[1] Nature, Nov. 29, 1877.

[2] In this chapter, where I am presenting the facts in a slightly different point of view, I am compelled unavoidably to repeat some of the instances given in the preceding one, for which repetition I trust the reader will forgive me. But whenever a reference has already been appended, I do not think it necessary to repeat it here.

[3] Log-Letters from the *Challenger*, pp. 150-249.

Next to red (with which must be included orange and yellow) in the order of æsthetic appreciation comes blue. This colour is comparatively common in nature, being the hue of the clear sky (in a few rare conditions only, for the sky of cloudy countries is whity-grey, and that of the tropics an indefinite haze), as well as of the enclosed sea in bays.[1] Moreover, it is wanting in luminous intensity, and is therefore very far from being a pungent colour. However, in the third factor of æsthetic effectiveness, the hereditary tendency of humanity, blue is doubtless comparatively strong; for a large number of fruits have a more or less bluish or purplish tinge. Accordingly, it ranks second in development amongst the favourite colours of mankind. Wherever only two hues are employed in decoration, those hues are generally red and blue. Indeed, if we use at random two words as summing up the totality of our colour-tastes, those two words will be red and blue. Yellow is æsthetically a mere species of red, while green has very little pleasurable effect, except to highly-cultivated eyes.

Accordingly, wherever a blue pigment exists in an accessible form, the use of blue is common. We have seen already that blue enamel, blue glass beads, and blue lapis lazuli occur in prehistoric remains; but the want of a proper dye seems generally to have prevented its popular use. Thus, while the Egyptians and Assyrians employed it abundantly, no trace of it occurs upon the Trojan or Mycenean pottery. But the ancient Welsh stained their bodies with woad, and all the Polynesian races tattoo themselves in blue lines. Many of the lowest Indian hill tribes—Kukis, Nágás, Todas, and Santáls—use indigo for dyeing cloth. The same dye is also widely employed throughout Central Africa. The bluish purple Bougain-

[1] I know no commoner instance of the inaccuracy of ordinary language with regard to colour than the familiar statement that the sky and the sea are blue. It is only true, when carefully tested, in about one experience out of fourteen.

villea almost vies with the crimson hibiscus in the favour of savages; and Bonwick mentions by name white, red, and blue species of flowers used by the Tasmanians in personal decoration.[1]

Green appears to me the least effective æsthetically of all colours: I mean, of course, to the ordinary mass of mankind, for it must be remembered that the cultivated taste generally gives a verdict exactly opposed to that of the multitude. It is the commonest of all colours in the natural environment of man; it has but little luminous intensity; and it is not connected hereditarily with any special function. Accordingly, I find it seldom mentioned among the decorative colours employed by savage tribes, and even then it is usually introduced as a contrast to red. While the Santáls wear strips of red, blue, and yellow cloth; while the Nágás dress in white cotton with red and blue fringes; I do not meet with any mention of green dyes among the Indian hill tribes. And this is very natural if we recollect that, amid their green leafy surroundings, it would yield very little contrast and possess very little decorative value. However, as we mount in the scale, we find that the women of New Guinea dye their petticoats red and green, with intermediate strips of yellow; while the Ashantis employ all four decorative colours, red, blue, yellow, and green. Of course, with the Mexicans, Peruvians, Egyptians, and Assyrians, all these colours were in common use, and green was raised to a place of equal importance with red and blue.

Yet, as a rule, where green rises to the position of a decorative colour, I am inclined to think that we can usually trace a special reason in the circumstances of the particular race. Green forms the opposite pole from red, in that red is the pungent and stimulative colour, while green is the restful and reparative colour. Owing to the large amount of green in the natural environment, our

[1] Daily Life of the Tasmanians, p. 27.

eyes appear to be adapted for continuous languid stimulation by that gentle excitant, which forms the mean of the total spectrum. On the other hand, owing to the ancestral habits of our race, our eyes appear to be adapted for sudden and pleasurable excitation by red, which rapidly glides into fatigue. Accordingly, we desiderate green as a relief. In the normal circumstances of humanity, surrounded by trees and fields, this relief is abundantly present. But in the civilised cities, with their greys and stone-blues, green does not occur with sufficient frequency, and hence it is hailed as a fresh and pleasant change. Added to which, it is joined in the civilised mind with various associated emotions, either actually felt or dimly suggested. And as its pleasure is the least directly stimulating, the most gentle and modest of all, it naturally ranks highest of any colour in the hierarchy of the æsthetically cultivated.

Now, it would seem as though the use of green in decoration were almost exclusively confined to those people who live an indoor life. It is among the civilised or semi-civilised nations that we see it most employed; and where it is found in the case of savages (as the Samoans and Hawaiians) it has generally been introduced from Europe or America. Moreover, it seems to be in special favour among the Persians;[1] and it may perhaps be suggested that Persia is a peculiarly arid country, where green is decidedly wanting in the landscape. It also ranks high among the Arabs, and among many inhabitants of cold climates. Those who have seen a Canadian Christmas, with its monotonous field of snow outside, and its gay decorations of evergreens and red berries indoors, will thoroughly understand the *rationale* of this preference.

To the last, the use of green remains chiefly supplementary. It is employed in bouquets as a relief, and in decorations as an element with red and blue; but

[1] Von Bezold, Theory of Colour, American translation, pp. 212, 215.

by itself it must be regarded as the least efficient of all colours.

It should be added, however, that from the beginning green seems to have been prized in such permanent forms as jewels or stones. Sea-green pebbles are mentioned among those buried in the barrows: and jade ranks as one of the commonest materials for polished hatchets. Greenstone, green jasper, and light green slate are also frequently employed for like purposes; and emeralds, malachite, or other similar minerals, have been universally prized for their beauty. The Central American and South American Indians seem to have had an extraordinary taste for green jewels, for which I confess I can see no sufficient reason. Perhaps it may have depended simply upon an accidental frequency of such stones in that tract of country. However, an explanation is here certainly desirable.

On the other hand, children and savages take little notice of vegetal greens, and usually arrange red and blue flowers entirely by themselves, without that admixture of relieving foliage which a more refined taste imperatively demands.

As regards the various mixed or intermediate colours—purple, orange, lilac, mauve, and so forth—their effectiveness depends mainly upon their similarity to red on the one hand or blue on the other. In proportion as they approach green they are less and less pleasurable: while, of course, those of the red end are, on the whole, greater favourites than those of the violet. Purple forms an intermediate term, being brilliant in the exact ratio of the red rays which it contains. Of course, among civilised people, such colours possess the additional charm of novelty and variety.

A few more words must be added as to the mode in which the various colours are used. In the earliest stage they are merely daubed on in isolation, as by the Andamanese who plasters his head with ochre, or the ancient Welsh who stained their bodies with woad. A little higher up in the scale, the colours are used in bars or strips, of violent contrast. Black, white, and red are the favourite pigments, each being well pronounced and standing out boldly against its neighbour. Then comes the addition of blue, and finally that of green. Above this level we find the employment of intermediate hues, such as yellow, orange, and pink. Last of all, the colours are mixed in shades of varying intensity, and we get the whole wealth of the entire spectrum, as in modern European art.

Again, the variety of form gives another element of evolution, into which, however, it would be improper to enter in the present volume, restricted as it is to the examination of the simple colour-sense. Here it must suffice briefly to point out the upward movement from the simple bars or strips of the savage, through the graceful curve lines of the Polynesians, to the arabesques and decorative harmonies of the Moors; or from the red and yellow imitative figures of the Hawaiians, through the bright primary wall-paintings of the Egyptians, to the landscapes and the figure-pieces which adorn the walls of our *Salons* and our Academies.

Both these lines of evolution, however, suggest a further consideration of great importance. While primitive man cares only for the pungent and brilliant stimulation of the primary colours, in all their fullest intensity of light, and pays little attention to their darker shades or duller mixtures, the æsthetically cultivated have learnt to notice and appreciate the fainter pleasures which arise from these slighter and more delicate stimulations. They are thus enabled to vary and enlarge their means of visual gratification, and to dispose their various-coloured objects in far more numerous and more subtle combinations. While the Australian knows only two or three invariable arrangements of red, black, and white, the civilised decorator is able to ring the changes perpetually upon ever-varying harmonies and contrasts of faint yellows, pale blues, rich purple-greys, and dark olive-greens. By artfully devising here a stimulation, there a relief, here a mass of comparatively brilliant pungency, there a field of mild retiring neutral tints, he succeeds in sustaining and recruiting the sensuous pleasure of colour from moment to moment, without ever causing us fatigue or overtaxing a single sentient structure.

And now we must pass on to a second point of view, that of the objects which are employed for the æsthetic gratification of the colour-sense. These, on the whole, afford a strong confirmation of the theory with regard to the origin of our æsthetic feeling which is here advocated, as the greater part of them consist of the very objects which owe their development to the colour-sense of animals.

Fruits themselves, though their utilitarian associations prevent them from standing in the front rank of æsthetic objects, are yet undoubtedly beautiful in colour and shape. And when we survey them amid their native boughs, few lovelier sights can be found than the brighter and prettier among them. An orange tree laden with its golden spheres, an apple orchard weighed down with its ruddy pippins, a holly-bush covered with its crimson berries, are some of the most exquisite pictorial sights which can be seen on earth. Especially æsthetic do fruits become, when, as in the case of the rowan, the spindle-tree, and the solanum, they are incapable of being used as food, and so can only minister to the pure pleasure of sight. In most instances, however, the beauty of fruits falls a little short of the æsthetic limit in the actuality, at least when they have been picked and are ready for table. Yet even so, when decorated with green leaves, and interspersed with flowers, their falling short is very slight indeed, if not purely hypercritical. But as objects of pictorial imitation they have always been in high favour; while they enter largely into the composition of poetry, as ideal stimulants of æsthetic feeling.

Nevertheless, it should be noted that fruits in the actuality are closely allied with the frugivorous instincts of our race, and that the origin of our whole taste for colour may still be clearly descried in the imprint which they have left upon our minds. Every child naturally puts a bright-coloured berry into its mouth; and it is difficult to keep the hands of urchins off the scarlet clusters of the arum or the brilliant crimson fruits of the yam. Even babies automatically strive to place every bright object which they see between their lips; and the sweetmeats which are manufactured for their pleasure bear attractive strips of red, blue, and yellow colouring. These and fifty other minor indications show us from moment to moment that the developed love for colour is a transference of feeling from its original alliance with the common food-stuffs of the species.

The æsthetic pre-eminence of flowers has never been doubted. In the actuality they form the commonest decoration of the savage home and the civilised garden, of the labourer's cottage and the royal palace. In imitation, they have been barbarously travestied with paper, wax, or feathers, and parodied in cotton upon bonnets, hats, or dresses. In the direct pictorial representation they have been favourite subjects of artistic handling from the days of the Egyptians downward. And as elements of poetry, they have been celebrated from the rose of Sharon and the hyacinth of Homer to Wordsworth's daisy and Tennyson's lily. But we must not forget that herein we are practically confessing the identity of our own colour-tastes with those of the bees and butterflies, for whose attraction these floral gems were first developed.

Fruits being, so to speak, the primitive and positive element in our love for colour, flowers may be regarded as one among the earliest classes to which the feeling is transferred. Even monkeys are not wholly insensible to their charms, though they display their affection, like our own little children, chiefly by pulling to pieces the objects of their regard. We have no evidence, of course, whether primitive man cared for flowers; but the presumption from the case of existing savages would certainly lead us to suppose that he did. I have already noted that the Tasmanians and Australians employ bright blossoms in their personal decorations; and the South Sea Islanders positively revel in garlands and nosegays. Even the stern American Indians show considerable love for these bright natural objects, and I find it noted of the Chibcha women that they wore flowers in their hair. A little plot of half-uncultivated garden commonly surrounds the very rudest huts. As to ourselves, so far as my observation goes, I am inclined to think that our children notice flowers as soon as they take note of anything which is not good to eat, while I had hard work in Jamaica to keep the hands of little negroes off the purple and crimson plants in my garden-plot. Finally, our own conservatories, flower-shows, and floral decorations show us the same taste pushed to its furthest extreme.[1]

It is worth while to observe, *en passant*, that though our children pick bunches of flowers they never pick bunches of leaves, a fact full of import as to the æsthetic value of green. Similarly, although adults intersperse their bouquets with foliage as a relief, they seldom arrange leaves by themselves. If they do, the leaves must present some special feature, like those of ferns, which attract us sometimes by their exquisite gloss, sometimes by their varied and minutely-symmetrical forms. So, too, when we place a flowerless plant in our gardens, it must either be recommended by such beauty of shape or gloss, as in the case of ferns, *Palma Christi*, and india-rubber trees, or by coloured foliage, as in the case of dracæna, coleus, caladium, sedum, and the other pretty plants at present so much in fashion. It is true a culti-

[1] Since this chapter was written, a most learned paper on "The Ceremonial Use of Flowers," by Miss A. Lambert, has appeared in the "Nineteenth Century" Review for September 1878.

vated mind may derive as much pleasure from a green leaf as from a scarlet geranium or a purple hyacinth; but then the pleasure in the former case is much more indirect, complex, and emotional, and in the latter cases much more immediate, pungent, and sensuous. Moreover, the first pleasure is personal and restricted; the second is generic and universal.[1]

This is, perhaps, the fittest place to advert to another curious fact, the fact that all our æsthetic feelings seem most deeply bound up with the relics of our original outdoor, arboreal existence. Fruits and flowers, birds and butterflies, sweet perfumes and songs of nightingales, the green fields and the luscious forests, these are deep and resonant elements in our perennial love for beauty. Mr. Herbert Spencer has pointed out that the pleasures of a day in the country, of wild scenery, and of free wandering over heath and moor, are largely due to unconscious recollections of the ante-civilised state. He even suggests that the enjoyment of a picnic, with all its unconventional delights, is mainly explicable as a sort of temporary reversion to a primitive state. Still more obvious does this become to those who have ever tried a fortnight of camping-out among the Thousand Islands of the St. Lawrence or the beautiful lakes of western New York. But it seems to me that we may go further, and ascribe our whole love of colour, perfume, and the more delicate

[1] I should like here to notice, parenthetically, an objection which has been urged by favourable critics against parallel passages in my "Physiological Æsthetics," and which will, doubtless, be urged in like manner against the above sentence. I have been accused of appealing from the cultivated feeling of the artist to the uncultivated feeling of the child and the savage, as though the latter were in some way truer and better. Such has never been my intention. I have only meant to appeal to the simplest individualities in order to find out what was primitive and original in our æsthetic nature, after discovering which we may proceed to explain what is derivative and advanced. But I confess that the feelings which a painter shares with a child and a barbarian appear to me more important subjects for philosophical investigation than the feelings which he only shares with a knot of some half-dozen associates belonging to the same highly-specialised artistic school.

taste of fruits, to half-remembered habits of our early ancestry. The acquired carnivorous mode of life sits loosely on the outer layer of our nature; but the hereditary frugivorous instincts seem to shape all our inmost feelings and sentiments. Bright hues, fragrant scents, sweet juices, these form the earliest pleasures of childhood, and remain throughout as the main sensuous factors of our æsthetic nature. The very fact of their comparative remoteness from our acquired and civilised habits seems to make them all the more distinctively beautiful and delicate. Thus, our modern dinner *à la Russe*, by removing from the table the coarse elements of meat and fish, while loading the white damask with flowers, with beautiful fruits, with coloured glass and porcelain dessert service, seems to recall whatever is loveliest and most æthereal in our ancestral traits. On a humbler scale, the mere decoration of dishes with parsley or watercress, the bouquet placed in the centre of the dinner table, and the very addition of cochineal to the jellies, or of egg and beetroot to the salad, points dimly back to the same half-obliterated habits, asserting themselves strongly throughout our whole history.

Both fruits and flowers are comparatively evanescent æsthetic objects. They soon fade and lose their beauty. But feathers, which perhaps rank next in order of historical occurrence, retain their brilliant hues for a considerable period. And just as our sense for the beauty of fruits and flowers is a proof of the community of taste which exists between frugivorous man and the fruit-eating and flower-feeding animals,—the parrots, toucans, humming-birds, bees, and butterflies,—so our sense for the beauty of feathers is an echo of the taste which originally produced them by sexual selection in the species to which they belong. Feathers form almost universal ornaments of savage or civilised humanity. The American Indians thrust them into their head-dress in the shape of a crest or crown. The Hawaiians wove from them their famous cloaks and idols. The Mexicans employed them for their beautiful mosaics. Eastern nations early prized the peacock for his splendid tail-plumes. And now, in our barbarous civilisation, millions of humming-birds from Trinidad and South America come yearly to Europe for the bonnets of our English ladies; ostrich-farms at the Cape supply our savage court-dress; and marabou plumes decorate the heads of our Belgravian beauties. The bird-of-paradise forms a regular article of commerce; grebe and swans' down line our mantles and jackets; even our very funerals are surmounted with the black-dyed nodding plumage of tropical birds. Our military officials wear feathers as the mark of highest distinction; and the heir-apparent to the British crown uses them as his armorial cognisance. Is it not worth noting, too, as a symptom of the permanent character which marks governmental ceremonial, that the use of feathers is especially bound up with our military system and court etiquette? Have we not here a direct survival from the simple ornaments of the savage chief?

Next, perhaps, in our conjectural order of transference might come the taste for shells, pearls, coral, and like organic substances. This taste we find almost universal among modern savages, and it extends far back into the prehistoric age. Mother-of-pearl is a favourite ornamental material, which has retained its popularity into modern times. Necklets of cowries or the turbo are common savage adornments, which have not yet died out in civilised lands. Coral still holds its ground in Europe, and large quantities are exported to China and Japan. On the whole, however, despite the few collections of shells on a cottager's mantelpiece, the love of these marine productions has died out far more than the previous tastes.

Coeval, doubtless, with the habit of gathering these treasures of the sea-shore is that of picking up bright-coloured pebbles or crystals. Of this we have already seen numerous examples, and further repetition would only fatigue the reader. A mere brief list of some principal varieties must suffice—such as the diamond, ruby, sapphire, topaz, garnet, carbuncle, amethyst, jasper, emerald, beryl, jacinth, onyx, opal, and turquoise; marble, porphyry, granite, serpentine, malachite, jade, fluor spar, amber, satin-stone, agate, alabaster, lapis lazuli, quartz, and bloodstone.

The use of decorative metals is closely bound up with that of the preceding class. The brilliancy and the colour of gold and silver early attracted the attention of primitive man. Used in conjunction with the precious stones, they compose what we know as jewellery, which forms one of the chief decorative appliances of all savage and civilised races. The taste which begins with the gold neck ornaments of the barbaric king, culminates in our own jewellers' shops, our regalia, our gold and silver plate, our city maces, our military uniforms, our ecclesiastical ornaments, and our Albert Memorials. Here, again, it is interesting to note the connection of state ceremonial and religious ritual with the earliest decorative devices of primitive chieftains.

All the objects which we have hitherto examined agree in one particular—they are self-coloured. Man finds them as he uses them, and transfers at once to the brilliant gewgaws the taste which was developed upon the bright-hued fruits. It is the property of natural colouration which gives to some of them their special value. Flowers and fruits, besides being transitory, are common and universal, and so they are only prized for their immediate beauty. Feathers and shells, though more permanent, are still too easily procured to rank high in exchange value. But jewels and precious metals, besides being indestructible, are naturally rare, and cannot be artificially multiplied; so that their value is proportionately and permanently great. Yet it may be noted that their æsthetic rank is not so elevated as that of flowers or even of beautiful feathers (though here many will disagree), partly, perhaps, because of the strong element of glitter and powerful total stimulation, but still more, I fancy, because the economical value has vulgarised them hopelessly, reducing them from the level of beautiful natural objects to the position of mere high-priced baubles.

The class which we have next to examine, however, is that of materials not naturally coloured, but artificially stained or dyed. Man at length progresses beyond the mere passive stage of æsthetics, and enters upon the active career of the artist. No longer content simply to gaze with pleasure upon the fruits, flowers, birds, butterflies, shells, corals, and precious stones which nature has beautified beforehand for his admiration, he begins on his own account to increase the stock of coloured objects by the application of pigment.

Pigment stands in the same relation to the natural taste for colour as sugar to the natural taste for sweetness, or artificial essences to the natural taste for perfume.

We get the first stage of this active process in the use of ochre, chalk, and charcoal, for the decoration of the hair and body. These pigments represent a very elementary form of painting, because in their case a friable substance is merely applied to another body, so that small fragments adhere by their own nature or by simple wetting. The expression of vegetable juices gives us a step in advance, as in the case of woad, indigo, logwood, and the like. The dyeing of cloth carries us still further on the upward march; and the discovery of mixed pigments, applied with a stamp or brush, puts a culminating touch to the process. Dyeing and painting revolutionise the whole environment of semi-civilised man, until at last, if the reader will cast his eye around the room in which he sits, he will see that scarcely an object can be found in it which has not received some purely decorative addition of pigment, stain, or polish.

Side by side with this great change goes the discovery of glass, porcelain, and other materials which imitate the natural colouring of precious stones. The numerous changes which can be rung upon these various materials, together with pigments, dyes, and textile fabrics, would demand a separate history, and cannot, therefore, be adequately treated in a single chapter.

But it must be remembered that while mankind have been transferring their native love for colour to these new objects, and exercising their sense upon these artificial stimulants, the taste must have been widening and deepening from day to day. It might have seemed to the reader at first that these æsthetic feelings, derived from a remote ancestry, must be growing perpetually weaker with the lapse of time, so that some fear might arise for their final obsolescence. But, really, man has gone on from age to age, surrounding himself more and more with beautiful flowers, bright clothing, decorative furniture, works of art, and all other exquisitely-coloured objects, so that what was at first a mere passing fancy for pebbles and shells, has developed at length into a perfect necessity of his fully-evolved nature. As an able writer in the "Revue Philosophique" has pointed out, even the veriest boor would now feel half his existence cut from under him if the whole æsthetic element were removed out of his life.

A third point of view must engage our attention for a while before we quit the subject of the æsthetic value of colour. I mean the gradual progress in *disinterestedness*, which marks the evolution of the æsthetic feelings.

The starting-point of visual æsthetics, as we have already seen, is the appreciation of bright colour in the fruits which form the common food of the original species. A close connection with vital function is here obvious and unmistakable. The simplest transference from this primordial pleasure consists, doubtless, in the mere transient interest in brilliant objects of the nearer environment, such as flowers, parrots, or butterflies. Not only the quadrumana, but savage or uncultured man himself, displays little interest in such intangible and distant manifestations of colour as the rainbow or the sunset. But monkeys are reported to pull to pieces handsome blossoms, to snatch the longer feathers from unsuspecting birds, and to dart after beautiful butterflies which flit past them on the wing in the bright sunlight. No doubt their interest is quite as momentary as that of the child who tears out the ray-florets of a daisy, or chases a Camberwell beauty across the meadow; yet if the facts as commonly related be really true, they show at least some slight disinterested love for colour, inasmuch as coloured bodies are instinctively selected as objects of passing pursuit, while green leaves or brown insects attract little or no attention.

The monkey, however, goes no further in his æsthetic career than this first simple step—for, of course, we must count the phenomena of sexual selection as manifestations of purely interested feeling. But man proceeds to employ the objects which he collects as means for his own personal decoration. The adornment of the body thus constitues the second stage of disinterested æsthetic progress. Flowers stuck into the rude head-dress, or woven into festoons for wreaths and girdles, form one of the earliest and most natural ornaments. But beautiful as these simple articles of dress must always be, they fade too soon for permanent use. Accordingly, shells, corals, pebbles, precious stones, feathers, and furs supersede them, where obtainable, as decorative appliances. The first function of pigment is for daubing the hair and body; while tattooing, originally a form of subordinative mutilation, grows at last into a mere æsthetic practice. As knowledge and arts increase, rude textile fabrics come into use, and being dyed or stained with red, yellow, and blue, form personal adornments for the savage chief. Of course, the whole original object of dress was that of decoration, the ideas of warmth and decency only coming in as afterthoughts at a later period. Amongst the lower races, men, not women, monopolise the handsomest costumes, which are worn as marks of distinction rather than as purely æsthetic adjuncts. Here, once again, we note that the employment of colour in male dress survives amongst ourselves mainly in connection with military, ecclesiastical, and governmental etiquette.

Yet even the humming-birds have passed beyond this second stage of disinterested æsthetic feeling, and reached the third step, which we have next to consider; for, as Mr. Gould tells us, they decorate their nests with pretty bits of lichen or brilliant feathers, interwoven with the materials of the outer wall. Much more have our old friends the bower-birds overstepped this higher limit, by positively instituting what may be described as *Assembly Rooms*, adorned with all kinds of coloured or shining objects. Obviously, the ornamentation of your home is one degree more disinterested than the ornamentation of your own person, and that of your temples or public buildings, one degree more so than that of your home. Both these steps are soon taken in the course of human evolution. The negroes of the Niger stain the exterior of their huts with blue and white; while the people of High Asia commonly paint theirs with grotesque figures. Amongst our own houses, external painting is, of course, very common, especially in countries where wood is largely employed as a building material. But internal decoration carries us a step higher, because it does not bear the same impress of mere ostentatious display; it shows more ingrained personal æsthetic sensibility, and less love of admiration at the hands of others. The West Indian negroes dress in very bright colours, and, on the whole, with admirable taste—the brilliant hues setting off with effect the natural darkness of their skin—but they seldom or never do anything toward the decoration of their huts, which are mere square blocks of mud wall, lightly roofed with palm-thatch. A step higher up, the West African negroes paint their huts externally, while inside they remain mere brown and dirty hovels. But the cultivated civilised man thinks more of surrounding himself, under his own roof, with beautiful and ennobling works of art, than of making a boastful external show before the eyes of his neighbours.

Under the same heading, we may notice the cultivation of flowers in gardens and windows. This practice exhibits a considerable advance upon the mere casual taste for picking pretty blossoms, and also upon the collection of naturally-grown flowers for personal decoration. It testifies to æsthetic forethought, and gives room for immense disinterested developments of æsthetic feeling. Gardens of more or less rude construction are found very far down in the scale of humanity, and they continue to be objects of solicitude up to the very highest level of civilisation.

The habit of keeping birds (especially those of bright plumage, like parrots, cockatoos, and peacocks) as domestic pets, deserves a passing notice in the same connection. How low down in the scale of civilisation this practice may extend I cannot say; but I observe that Captain Moresby[1] mentions it as prevailing among the savage Papuans.

If the mere common savage decorates his own little hut with pigment, skulls, shells, and flowers, much more will the great chief gather around his dwelling these æsthetic adjuncts, and others of higher kind. Only kings in Hawaii were permitted to use the feathers of the Melithreptes, from which the royal robes were woven. Purple has always been a *peculium* of kingship, and the palace is naturally thought of as a finer and more brilliant building than the hut or house of a subject. Even the veriest savages have distinctions of dress and decoration for their chiefs; and when we come to the royal abodes of Egypt, Assyria, Mexico, and Peru, we see at once how large a share monarchy has borne in the development of artistic handicraft, which, of course, entails a corresponding

[1] Discoveries in New Guinea, p. 219.

development of the æsthetic feelings. Solomon's house and ivory throne,[1] as well as his "apes and peacocks,"[2] will immediately occur to the Biblical student. If we trace this influence down through history, we shall find that princes have always been the great patrons of fine art, and that painting in particular has been almost entirely fostered under the protection of monarchs and aristocracies.[3] But these royal decorations react upon the popular taste, and finally afford new outlets for the disinterested æsthetic sentiment of the people. Hitherto, the sense of beauty has been more or less linked with the feeling of proprietorship: beyond this line it gains more and more, with every step, in abstractness and remoteness from the personality of the individual.

Religion, however, does still more for the æsthetic sentiment than even governmental adjuncts. If the house of the chief receives exceptional decoration, much more does the house of that deified ghost-chief, the god. Wherever we look, we see that all the resources of art, infantile or full-grown, are most fully employed in the service of religion. Painting, sculpture, music, the thousand minor arts of decoration and dress, all combine to do honour to the gods of the country. From the West African fetish, through the Polynesian shrines, the Indian topes, the Chinese pagodas, the Mexican and Peruvian temples, the mysterious colonnades of Egypt, the massive architecture of Babylon or Nineveh, the Hellenic Parthenons, the Italian Capitols, to the modern mosques of Islam and the towering cathedrals of Christendom, we find the highest artistic handicraft of every age and race lavished upon the dwelling-place of the national deities. The few traces of æsthetic feeling in the Hebrew Scriptures

[1] 1 Kings vii. [2] Ibid. x. 22.

[3] Thus it turns out that (paradoxical as it must at first sight appear) even kings and queens are not without their ultimate uses. It has often struck me as a curious fact that had it not been for the royal parks and gardens, London and Paris would have been left almost entirely destitute of open breathing-spaces.

are connected with the workmanship of the Tabernacle, the Temple, and the hieratic dress. I have pointed out elsewhere[1] how large a part the religious sentiment has borne in the genesis of the sublime: it must here suffice thus briefly to hint at the impetus which it has given to the kindred feeling of the beautiful. Whether we look at the endless painted images of Karnak or at the stained windows of Salisbury, we must equally recognise the enormous influence of religion in the growth of disinterested æsthetic feeling.

The remaining steps of the process would carry us too far into the general realm of æsthetics, if treated in full detail. Enough has been done already to show the main course of evolution, whereby the love for colour becomes extended and divorced from the personality of the sentient mind. The final step, it seems to me, is taken, when we arrive at the pure love of colour in nature for its own sake, the love which draws the cultivated man to gaze with delight upon the autumn hues, the rainbow, the sunset clouds, or the myriad tints of sea, and sky, and plain, and forest. In works of art, so many additional factors of plot-interest, of admiration for imitative skill, or of critical appraisement, enter into the total of our consciousness, that we can hardly analyse our feeling into its simple constituents; but when we look upon the crimson and golden hues of evening, the thrill of pleasure which echoes through our brain represents, I believe, almost the purest form of disinterested love for mere colour.

[1] See "The Origin of the Sublime," in "Mind" for July 1878.

CHAPTER XIII.

THE GROWTH OF THE COLOUR-VOCABULARY.

THE names of colours are abstract words: they represent an attribute, not an object. Accordingly, they do not belong to the class of words which form the vocabulary of young children or of primitive men. They arise gradually, during the course of human evolution, personal and collective, in proportion as they are required by the needs of the individual or the race. A child of two years old (or a little more) knows very well the names of grapes, strawberries, and oranges; but for purple, crimson, and orange as a colour, it has as yet no appropriate verbal symbol.[1] If you ask it what it calls these things, it will answer at once, "glape," "tlawbellie," or "olage," as the case may be; but if you ask it, "what colour is this?" it has no answer ready, because it does not even comprehend the question.

Intelligent adults who have received a philosophical education—or rather, an education in philosophy—have grown so accustomed to the conception of substance as composed of attributes, so habituated to the analytical mode of regarding concrete objects, that they find a difficulty in realising the mental state of the unsophisticated human being. An educated man, if asked to describe a grape, would answer, "It's a small, round, sweet, purple

[1] I am not speaking here by guess-work, but stating the result of numerous actual experiments.

fruit, which grows in clusters on a twining vine;"[1] but a labourer would have recourse to better known concrete objects, and reply, "It's something like a plum, only about the size of a cherry, and grows in bunches the same as currants." Or again, if a naturalist discovers for the first time a new animal—say an argus pheasant—he will minutely characterise its shape, size, colour, external appearance, and internal structure, detailing all these points in extremely abstract language; whereas, a countryman who goes to the Zoological Gardens will simply describe it as "between a peacock and a guinea-hen." In every case, the average intelligence of mankind endeavours to grasp an idea by means of concrete realities. Only by an effort is it able to resolve the complex whole into its ultimate analytic constituents.

We shall fall into many errors, therefore, if we insist upon reading the simple language of primitive man by the light of our developed experience. Evolution for ever impresses upon us the lesson, that if we would be good philosophers we must forget our philosophy. Thus, the formal logician was prepared to interpose his learned objection just above, when I said that the names of colours are abstract. For the purposes of his artificial system, with its propositions and denotations and intensions, blue and green are concrete terms. I have no fault to find with the expression; when writing logically, we must all allow the truth of the distinction. But from the point of view of psychology, every word which does not denote a concrete thing in its totality, or a picturable action, must be regarded as abstract. While general

[1] I have purposely given the natural answer of an ordinary, well-educated, non-botanical speaker. But see how absurdly inadequate the description really is! Setting aside its total want of structural detail, and merely regarding it from a practical point of view, what a vague expression is *small*, in lieu of a measured diameter, *round*, instead of spherical, and *sweet* as a symbol of the compound and delicate grape-flavour. Then, again, we have no information whether it is a "stone-fruit" or a "berry," and whether it is edible or poisonous. Yet the description is really a very good one as descriptions go.

names are *not* real abstractions, because they describe indiscriminable individuals,[1] adjectives *are* real abstractions, because they describe a single property viewed in isolation from the other properties of the objects in which it is an element.

The names of colours, then, are abstract words; but, like all other abstracts, they necessarily take their rise from a concrete. A moment's reflexion will show us that the evolution of language could not proceed otherwise. The earliest names must be names of things or of visible and audible actions. These must afterwards be applied to other like things or to similar attributes, by slight changes in their meaning. Unless primitive man in the search for a means of intercommunication had hit upon the plan of framing a conventional word to express an abstract idea—a plan obviously itself too abstract in its nature for adoption by any but a high order of intelligence—he must clearly proceed by forming new words out of the old, by likening the unnamed to the nameable. And as a matter of fact, philological analysis shows us that such has been the actual course of development—that every abstract word can be ultimately traced back to a root of extreme concreteness, and every expression of attribute can be shown to belong in its origin to a definite subject.

It would be easy to give a philological analysis of the common colour names, such as red, green, blue, and yellow, in several ancient and modern languages, which would bear out the truth of this assertion; but I prefer to take

[1] I have no room here for the discussion of this side-issue, but I may just point out in passing that the word *man* is not in practice arrived at (as logicians tell us) by abstracting from the various individual men what is common to each, but by the childish mind recognising originally a number of exactly similar units, some of which it afterwards learns to discriminate. A child at first regards all men as "Papa;" it only slowly grows to demarcate the actual Papa from other men. We recognise *meat* before we recognise *beef* and *mutton*; or *tree* before *oak* and *elm*. Nobody knows one pin or one egg from another; they are thought of as the same: and if we are shown two in succession or the one twice over, our impressions are absolutely identical.

examples from a later date, and to show the origin of one or two very new expressions, whose meaning is too plain to admit of any doubt. Though this method has far less appearance of learning than the other, it carries a great deal more conviction to the general reader: for we can easily see that *rose-coloured* is directly derived from the known word and the known concrete object, a rose; whereas most people must take on trust the origin of *brown* from an Indo-European verb meaning to burn, or that of the heraldic *gules* from a Persian word *ghul*, which designates the same favourite flower.

Among such new terms of undoubted derivation, we may take as specimens *lilac*, *lavender*, and *violet*, which are borrowed from the concrete names of flowers; and *orange*, *cherry*, *apple-green*, which are borrowed from those of fruits. So, too, to go a little further back, we have *pink* from the well-known blossom; and the almost obsolete *saffron*, a favourite colour-epithet with Elizabethan poets. Again, we find the French words *cerise*, *mauve*, and *écru* in common use among drapers and their lady-customers; and when we inquire into their meaning, we see at once that the first is the same as our *cherry*, the second is the name of the marsh-mallow, and the third (literally *unbleached*) is a derivative of the Latin *crudus*; so that in every case, when we go back a little way, we see that the abstract colour-term is always a special application of a very concrete primitive object-name.

In fact, when we wish to express a hitherto unnamed colour, the simplest way of doing it is to take an object which possesses that colour, and apply its title as an adjective to the thing which we wish to describe. A particular shade of very light yellow has no distinctive name at a particular time; but we must call it something for some special purpose, and so we think of its nearest common representative, a primrose. Thenceforward, the new name becomes an adjective, and we ask naturally for a yard of primrose ribbon. Now, what we see civilised men doing to-day under our own eyes, primitive men did centuries ago, when they framed the earliest colour names. It would seem at present as though the various terms for colours might be divided into two classes, the truly abstract, such as *blue*, *green*, *yellow*, and the concrete used abstractly, such as *lilac*, *orange*, *pink*. The former class appear to have no other meaning than that of pure colour; while the latter class are clearly derived from the names of concrete objects. But in reality, the difference between them is merely one of time. Abstract colour terms are the names of concretes, whose original signification has been forgotten.

Yet another general principle of vocabularies must be considered, if we wish rightly to comprehend the growth of colour names. Words arise just in proportion to the necessity which exists for conveying their meaning. For example, to take the specific case of colours, we have seen a large number of colour terms introduced within our own memory, because the hues to which they referred had become fashionable as dyes for dress materials. Such are the instances of *mauve*, *écru*, *solferino*, *magenta*, and *cardinal*, every one of which has obtained a definite name only because it had been employed in the drapery trade. In short, we invent words as we need them.

Armed with these general truths, let us endeavour to trace out the origin and development of the colour-vocabulary.

Primitive man in his very earliest stage will have no colour terms whatsoever. He will speak of concrete objects only, and when he uses their names he will use them as implying all their attributes. He does not need to say *red blood*, for all blood is red; nor *green leaves*, for all leaves are green. *Blood* and *leaf* by themselves are quite sufficient for every one of his simple purposes.

But when man comes to employ a pigment, the name of the pigment will easily glide into an adjectival sense. The earliest colour terms will thus be produced. I learn from Mr. Whitmee that the Samoans use three kinds of pigment—a red volcanic earth, a molluscan purple, and a turmeric; and the names of these three pigments are applied as colour terms.[1] So, too, many other informants have given me like instances with other races. A large proportion of our own colour terms are derived from dyes or pigments. Such are *crimson* (or *cramoisi*) from the Arabic *karmesi*, the kermes;[2] *vermilion* or *vermeil*, from *vermiculus*, because it was supposed to be the product of a worm;[3] *gamboge*, from Cambodia, the place of its export;[4] *indigo*, from Spanish *indico*, the Indian dye;[5] and *saffron*, from the common English plant.

Moreover, we saw that red is the earliest colour used in decoration, and accordingly it is the earliest colour which receives a special name. This fact has been fully brought out by the researches of Geiger, Magnus, and Mr. Gladstone; and it will not therefore be necessary to accumulate further proofs in the present volume. The early prominence of red, however, has left some curious traces in language, as well as in art, to the present day, which deserve a passing notice here. Thus the Indo-European dialects contain a number of words for this colour from a common root—*e-ruth-ros, rubeus, russus, ruadh, roth, red, rouge, robbio, roux, ruddy*, &c.; while there is no such widespread and common root for blue—*cæruleus, blau, azul*—

[1] In this case and in many others, correspondents have kindly supplied me with the words used by existing savages, or by early historical races, such as the Assyrians, Hebrews, and Peruvians; and I might have given a certain false show of erudition to the present chapter by inserting the original terms as given. But really the important point for our purpose is the existence of the words, not their particular form, which is only valuable for philological students. The reader would be none the wiser if I had stated that these forms in the case of the Samoans were *ele*, *pauli*, and *lenga* respectively. Accordingly I have only inserted original words in the text when they belong to languages with which I am personally acquainted, and with which I may reasonably expect a fair familiarity on the part of the reader.

[2] Brachet, Dictionnaire Etymologique de la Langue Française, *sub voc.*

[3] Ibid., *sub voc.*

[4] Isaac Taylor, Words and Places, p. 409.

[5] Ibid., p. 409.

nor for green—*chlôros, viridis, grün.*[1] Again, we English have a great number of subordinate colour terms in popular use to express the various shades of red, such as *crimson, scarlet, vermilion, rosy,* and *pink,* besides less definite words like *cherry, ruddy, russet, carnation, blushing, sanguine* or *ensanguined, ruby,* and *roseate;* but we have few or no words to express the shades of green, while physicists have had to introduce the conventional terms *indigo* and *violet* to designate the widely different but unnamed hues which result from the quickest light-waves. Once more, while the nouns of brightness and its opposite give us the verbs *to lighten* and *to darken, to whiten* and *to blacken,* and while the primitive art-colour, red, gives us the verb *to redden,* we have no such words in our language as *to bluen* and *to greenen.* And it is a significant fact, as regards the æsthetic position of green, that whereas the use of "blue" in laundries has given rise to a technical verb of washerwomen, *to blue,* we have absolutely no verb meaning "to green" or "to viridise." Finally, the mixed colours, orange and purple, into which red enters as an element, have separate popular names, but no other mixed colours have any but technical designations; and while these red-like words, with yellow, the adjunct of red, yield us the verbs *to purple, to crimson, to encarnadine, to ensaffron,* and so forth,[2] I cannot call to mind a single similar expression with reference to the less refrangible rays.

During the period or stage in which red forms the main or only decorative colour, red alone has a conventional or abstract name. All other hues are spoken of by comparison with well-known objects. It is not the habit of the early mind to refer to the sky as *blue,* or the leaves as

[1] Curtius, however ("Griechische Etymologie," *sub voc.*), identifies the roots of *chlôros* and *viridis.* I must almost confess to a little scepticism; but the identification, if true, would show that green was discriminated and named before the separation of the Hellenic and Italian race from their Aryan ancestors.

[2] It should be added, however, that these words are largely due to the special poetical effectiveness of red, concerning which more hereafter.

green; on the contrary, it speaks of blue things as "sky-faced" (*cœruleus*), and of green things as "sprout-like" (*viridis,* connected with *virere; grün, green,* connected with *grow*). The primitive man would no more think of saying that the sky was sky-faced, or the leaves leaf-like, than we should think of talking about an orange orange, or a lilac lilac.

But so soon as blue becomes a recognised art-colour, either through the use of pigments or of decorative jewels, a name for blue springs up. One of the commonest in Europe is that of *azure, azur,* or *azul,* derived from the Persian *lâzur,* lapis lazuli.[1] We have already seen that this stone was very early imported from the east, and it was natural that it should give a name to the hue in question, because it was largely employed for artistic purposes. *Emerald* and *turquoise* are similarly used at the present day to designate various shades of green.

At this second or red-blue stage, the word for blue seems often to be applied also to green. This is not surprising when we recollect how very little difference really exists between these two colours. Indeed, I am convinced that we only have separate names for them at all because the commonest green in nature, that of foliage, and the commonest blue in nature, that of the seldom-seen open sky, are so very wide-spread and so much more strikingly different from one another than most blues and greens. But if we look at a turquoise, it is very hard to say whether we should assign it to the former or the latter colour; while the sea is just as often the one as the other. The original assumption of some natural object on the borderland between the two as the concrete name-standard would quite sufficiently account for the common confusion

[1] The dropping of the initial *l* is probably due to its being mistaken for the definite article—*l'azur*. The analogous cases of *an adder* for *a nadder*, and *un orange* for *un narange* (Spanish, *naranja;* Arabic, *nàranj*), or the converse instances of *a newt* for *an eft, le lierre* for *l'ierre* (*hedera*) will occur to all philological readers.

between them in language. As a matter of fact, Mr. Whitmee informs me that the word for blue in Samoan is literally *sea-colour*. The Welsh use *glas* indiscriminately for both; and the Assyrians, according to Mr. Sayce, described green as either blue or yellow; but we know in each case that the colours themselves were or are acurately distinguished. The Quiché Indians had also one word, *rax*, for green and blue;[1] yet there can be little doubt of their proper perceptions. I believe the same explanation must be offered of the alleged fact that the Burmese confuse these two central colours; but I have not been able myself to examine Bastian's account, and the gentlemen in Burma to whom I addressed inquiries on the subject did not reply to my circulars. At any rate, in Burmese works of art, blue and green are acurately discriminated, and blended with great taste. Certainly, Professor Blackie showed, at a meeting of the Royal Society of Edinburgh, that the Highland Scots, who call sky and grass both *gorm*, could perfectly discriminate between the two colours when tried by practical tests. It may be added that certain hues which we ordinarily class roughly together as reds, for instance that of bricks and that of some light pink geraniums, are quite as far apart from one another in consciousness as the green of the emerald and the blue of the sapphire.

Yellow generally takes its first name from gold. *Aureus* is the common Latin epithet, and *golden hair* still passes muster in everyday colloquial English. Von Bezold has shown that yellow seldom enters into decorative art except in a metallic form, and that it never rises to the same distinct æsthetic prominence as red, green, and blue.[2]

Green, above all other colours, has few names derived from pigments, because it is so seldom employed for decorative purposes. Most of its designations are directly

[1] Scherzer's Ximenez, p. 15, note.
[2] Theory of Colours, American translation, pp. 138, 181, 194.

derived from grass or leaves; the remainder belong originally to fruits, to the sea, or to precious stones.

And now we have reached the point in the development of the colour-vocabulary at which most semi-civilised nations, all children, and the mass of uneducated adults, always remain. Six colours are commonly recognised by the popular mind—black and white, red and blue, green and yellow. The first pair, of course, are merely words for the total beam and its negation; the second pair form the earliest æsthetic analytic colours; and the third complete the ordinary differentiation. Add grey and brown for the intermediate or muddily-mixed shades, and we have the full colour-vocabulary of everyday life. Even the educated only speak of scarlet, crimson, lilac, and purple under exceptional circumstances, as in literary composition or for technical purposes; but to the mass of mankind these lesser distinctions of language are wholly unknown.

Heraldry has stereotyped this conception of colour in its set language of *or* and *argent; gules, azure,* and *vert;* and *sable.* Here we have two metallic colours, those of gold and silver; and four non-metallic, black, red, blue, and green. Of the latter, one name, *gules,* is of oriental origin, and, doubtless, points to some imported Arabic pigment (perhaps vermilion); one, *azure,* is also oriental, and has been already explained; the third, *vert,* is Latin and imitative; while the fourth, *sable,* is derived from *zibellino, sibelino,* or *siberino,* the Siberian fur.[1] The only compound colour known in heraldry is *purpure,* while *vair* and *ermine* are, of course, mere names of light and shade in material.

The further differentiation of the colour-vocabulary depends, as before, upon the practical needs of intercommunication. It is most developed among three classes of persons. The first class is that of dyers, drapers, milliners,

[1] Isaac Taylor, Words and Places, p. 415.

and others who have to deal with coloured articles of clothing; their vocabulary includes numerous words, such as *cherry*, *cerise*, *lavender*, *lilac*, *mauve*, *solferino*, *magenta*, *écru*, *primrose*, and *cardinal*, besides purely technical names like *Paris-in-flames*. As might be expected from the usual course of fashion, a large proportion of these are French. The second class includes painters and other artists, whose colour-vocabulary consists largely of pigment names, such as *lake*, *madder*, *ultramarine*, *carmine*, *Prussian blue*, *gamboge*, and *ochre*. The third class is that of scientific physicists, whose language comprises terms like *cyanogen-blue*, *carnation*, *indigo*, *apple-green*, and *sulphur-yellow*. It may be added that the introduction of fresh pigments from time to time produces a direct result in enlarging one or other of these various lists. Thus, the common use of aniline dyes at the present day has given rise to a considerable number of new colour-terms.

Furthermore, special technical colour-words are used in restricted senses as applied to animals or other objects by different trades. Thus the names *chestnut*, *bay*, *sorrel*, and *roan* are only used of horses; while *black*, *white*, *grey*, and *cream-coloured* are employed with specialised significations of the same animals. Cats claim a monopoly of *tortoise-shell*; and *tan* (in the phrase *black and tan*) forms the peculiar property of terriers. Hair alone is *auburn*, and only eyes are *hazel*.

It may be interesting, before we pass away from this part of our subject, to give a brief formal classification of the various concrete origins from which abstract colour-adjectives have been derived. I shall take my examples only from the commonly-known English words.

Two main classes may be distinguished — the Pigmentary and the Metaphorical.

Pigmentary colour-names fall under three heads. First, the material—as *vermilion*, *crimson*, *saffron*, *indigo*; second, the local—as *gamboge*, *Prussian blue*, *Paris green*; third, the conventional or artificial—as *magenta*, *solferino*, *cardinal*.

The last-named head is quite modern, and of slight philological value. It belongs to the *conscious* stage of word-making.

Metaphorical colour-names fall under four heads. First, elemental—as *sky-blue, sea-green, muddy.* Second, vegetal—as *green,* from foliage; as *pink, violet, rose, lavender, primrose, lilac,* from flowers; as *orange, cherry, chestnut, hazel,* from fruits. Third, mineral—as *golden, silvery, azure, sapphire, ruby, emerald, turquoise, amethyst, amber,* and *jetty;* with which we may fairly class certain animal epithets, such as *coral, ivory,* and *pearly.* Fourth, miscellaneous—as *sable, sanguine, snowy, chocolate.*

And now we must pass on to a second question, the reason for the great vagueness of all colour terms.

I believe the solution of this difficulty is to be found in the nature of the colour sensations themselves. They are nowhere clearly marked off from one another by definite lines. The solar spectrum contains an infinite gradation of hues, each of which fades into its neighbour by imperceptible degrees. It is impossible to name them all, because their number is really incalculable. Hence we are reduced practically to inventing names for the most prominent.

A glance at the other senses will throw much light upon the present problem. In taste, we distinguish a fairly large number of sensations by separate names—*sweet, bitter, pungent, sour, acrid,* and so forth; but we have no separate word for the flavour of a peach, a strawberry, and a grape. We refer to them by the concrete name of the object as a whole, just as primitive man does with the colours. In smell, we have even a smaller number of distinctive terms, for we only speak of them as sweet or stinking; and these words refer, not to the intelligible qualities of the scent, but simply to its emotional aspect. In hearing, we generally employ the two expressions *high* and *low,* or their equivalents, *treble* and *bass.* But here we have elaborated for special technical purposes a far more accurate and quantitative nomenclature; a nomenclature infinitely superior to that of any other sense, not excepting the sense of colour. The division of the audible gamut into octaves and notes, further divisible into semitones, and for very discriminative ears into minor fractions, down to one-sixty-fourth of a tone, enables us exactly to express in language the very minutest possible varieties of sensation. This admirable system of nomenclature is rendered practicable by the peculiar constitution of the ear, and by its special adaptation to the regular harmonic intervals.

In sight, however, no such minute discrimination is possible. We can indeed divide straight lines into inches, half-inches, and eighths-of-an-inch; while the microscope further enables us to discriminate decimals, hundredths, and so forth, down to extremely minute fractions. But in colour our eye is not fitted for noting at once the relative distance of rays in the spectrum, as our ear is fitted for noting the relative distance of tones in the gamut. Accordingly, we must have recourse to some artificial system.

Such a system was proposed by Chevreul in his "Exposé d'un moyen de définir et de nommer les couleurs d'après une méthode rationale et experimentale;"[1] but, unfortunately, that great chemist took for his basis the mixture of *pigments*, not that of *rays*;[2] and his method is consequently incorrect and insufficient.

Another plan, in common use amongst physicists, is to designate the colours by their proximity to one of the lettered lines in the solar spectrum. Thus cyanogen-blue may be approximately defined by saying that it lies a little to the violet side of the line F. But this plan is, of

[1] Mémoires de l'Académie des Sciences, vol. xxxiii., 1861.

[2] For an explanation of this cardinal distinction, too fundamental for exposition in the present volume, see Helmholtz's classical work on "Physiological Optics." The English reader will find a lucid *résumé* of the question in Professor Tyndall's little book "On Light."

course, too indefinite and too little numerically accurate for scientific use.

The only perfect method would consist in an artificial division of the solar spectrum into a number of equal parts, say one hundred, and the invention of a separate name for each such hundredth part. This system has been partially carried out, though in a very complicated manner, in Lambert's colour-cone, adopted as a basis by Helmholtz and Clark Maxwell. The only further modification required, is that of an extended numerical nomenclature.

Before we go on to examine the application of the general principles here laid down to the special cases of the Hebrews and the Homeric Akhaians, adduced by Dr. Magnus and Mr. Gladstone, it may be worth while to glance briefly at the special poetical effectiveness of the colour-vocabulary. As the authors of the Akhaian epics, and of many among the Hebrew books, were themselves poets, the use of colour terms by other poets may help us to estimate more correctly the true value of the evidence in their cases.

Red is pre-eminently, and beyond all comparison, the poetical colour. It is applied to every object which by any straining of courtesy can possibly be conceived as possessing it; and it is often attributed to other objects which have no claim whatsoever to the title. Thus we have red gold, red lions, red right hands, red kings, the red Douglas, and even red wrath. The great red sun sinks nightly, amid red clouds, into the red waters of the sea. Rosy-fingered dawn spreads crimson glories over the empyrean; the scarlet flush of eventide encarnadines the fiery sky. A great many reasons conspire to produce this effect. In the first place, red, as we have abundantly seen, is the most universally pleasing of all colours. Then again, it was the first colour employed in art-workmanship, and so, as Mr. Gladstone graphically puts it, "got the start" of all the others. This further secured it a certain poetical prescriptiveness, especially as a stock epithet in some well-known conjunctions, like those noted above. Finally, its special use as an adjunct of royalty or state ceremonial gives it a peculiar claim to poetical use.

Now, I am not a great believer in that system of word-counting which is so favourite a device with Mr. Gladstone. It appears to me a fallacious and illegitimate application of seemingly rigorous statistical methods, for the value of the word can never be properly appreciated apart from its context. Nevertheless, in order to meet the enemy with his own weapons, I have counted up all the colour-epithets in Mr. Swinburne's "Poems and Ballads," a volume which I have purposely selected, because it represents the spirt of traditional poetry in its purest form. I find the results to be as follows:—The word *red* occurs in all 151 times, together with *rosy*, *crimson*, once each, and *sanguine*, *ruddy*, *scarlet*, twice each: total of the pure red epithets, 159. *Yellow* is mentioned 13 times, *tawny* once; but the more poetical word *gold* numbers 113 repetitions, and *golden* 16: total of the yellow epithets, 143. *Purple* comes in for 23 notices. Grand total of red-end epithets, 325. On the other hand *blue* occurs 25 times, and *violet* once; total, 26. Green obtains mention in 86 places. Total of the violet-end epithets, 110. The only other colour term is *brown*, employed 10 times. Now, I acknowledge that this is an *ex parte* statement, for three reasons: I have reckoned the word *gold*, which is sometimes a noun and sometimes an adjective, as though it were always the latter; I have counted *purple* as a red-end word, though it might equally claim to belong to the violet; and I have clubbed together red and yellow. But Mr. Gladstone also makes *ex parte* statements, and mine seem to me much more justifiable than his. For gold is undoubtedly a favourite word in poetry, largely on account of its colour and glitter; purple undoubtedly owes its effectiveness to its red, not to its blue element; and the yellow of *golden* is a colour which may very fairly rank with red and orange. On the other hand, I have allowed all the *greens*, though many of them are not colour-words at all, and though the number of objects which may properly be called green is out of all proportion to the number of objects which may properly be called red. The true significance of the list is best seen by comparing the 25 *blues* with the 151 *reds*. To adopt the statistical form, we might say (if we chose to reckon the unreckonable) that red is 500 per cent. more poetical than blue!

For comparison with these results, I have also extracted the colour-words from Mr. Tennyson's "Princess," and I find they stand in the following proportions:—*Red* occurs 10 times, *crimson* 3, *rosy* 3, *rosed* (as an adjective) once, *ruby* once, and *rubric* once; while the verb *to redden* has also one mention. *Golden* is employed 13 times, *gold* 7, *gilded* 3, *gilt* twice, *yellow* once, *orange* once, and the verb *to gild* once. *Purple* occurs 6 times, *purpled* once, and *empurpled* once. Total of the red-end epithets, 56. On the other hand, *green* is used 5 times (not always as a colour term), *blue* once, *azure* three times, *lilac* once, and *violet* once. Total of the violet-end epithets, 11. So that Mr. Tennyson also finds red and yellow just five times as poetical as green and blue.

There are, however, some other more useful deductions to be made from the above lists. Observe, in Mr. Swinburne's case, the want of variety, the paucity of colour terms as a whole—the total absence of *orange*, *lilac*, *pink*, *azure*, *saffron*, *vermilion*, or *lavender*. This absence is due to the fact that Mr. Swinburne faithfully echoes the old ballad poetry, with its relatively poor but strong vocabulary—its preference of bold outline to finished detail. There are none of the conventional prettinesses of the eighteenth century; none of the refined distinctions of our modern miniature word-painters. Mr. Tennyson puts in colour phrases with the fidelity of a Dutch landscape;

but Mr. Swinburne throws on his broad contrasts with the rich sensuousness of an Egyptian or Mediæval colourist.

Observe, too, the preponderance in both poets of *gold* and *golden*. The secret of this peculiarity is to be found in the emotional associations of costliness which the words suggest. So we find the poets (especially the commonplace) are fond of silvery locks, coral lips, sapphire seas, ruby wine, emerald eyes, amber tresses, ebon locks, pearly teeth, and ivory brows. All these points serve to elucidate the real nature of the poetic colour-vocabulary. It is archaic, it seeks immediate effect, and it lays stress upon associated emotions.

In order further to impress these facts, I have analysed a few examples of well-known English poetry, and extracted the colour terms, or words bearing on colour, and with the following results :—

The first two books of Mr. F. T. Palgrave's "Golden Treasury of Songs and Lyrics," embracing the Elizabethan and Miltonic periods, contain : pure colour-epithets—*red* 8 times, *green* 6, *blue* 16, *yellow* 4 ; impure colour-epithets—*blushing* 2, *crimson* 2, *ruby* 2, *vermeil* 2, *bricky* 1, *sanguine* 1, *rosy* 3, *cramasie* 1, *russet* 1, *purple* 4, *orange* 1, *saffron* 1, *golden* 13, *gilded* 1, *greenish* 1, and *azure* 1. *White* occurs in 18 places, *black* in 6, *snowy* 2, *whiter* 1, *sable* 4, *ebon* 1, *swart* 1, *grey* 3, *brown* 2, and *nut-brown* 1. Among concrete coloured objects, *flower* is mentioned 28 times, *posy* twice, and *blossom* once ; *rose* 21, *lily* 7, *daffodil* 2, *daisy* 3, *violet* 4, *primrose* 2, *cowslip* 1, *may* 1, *pansy* 1, *woodbine* 1, *jessamine* 1, *crow-toe* 1, *pink* 1, *garland* 4, and *flowery* 2. *Cherry* occurs 6 times. *Gold* counts for 6, *pearl* 6, *diamond* 1, *coral* 5, *amber* 2, *sapphire* 3, *silver* 8, *ivory* 1, and *crystal* 8. *Sunset* and *rainbow* are mentioned once each. The only other words suggesting colour are *ensaffron* and *variable* in the sense of *variegated*.

This list, I think, serves to show two or three of our main points. In the first place, it is quite clear that if we take the various red and yellow adjectives, and their corresponding concretes, they enormously outnumber the greens and blues. Next, it is instructive as showing how unfair is an enumeration by simple epithets alone. Again, the number of metaphorical colour words which it contains must strike us at once. And, lastly, the number of allusions to gems, or their organic equivalents, is very great.

Gray's "Bard" yields as follows:—*crimson, ruddy, blushing,* and *golden,* once each, *sable* twice. Shelley's "Skylark," *golden* twice, *purple, green, blue, white,* and *silver,* once each. Shelley's "Euganean Hills," *green* three times, *red, purple,* and *golden* twice each, *crimson, blue, azure, sapphire-tinted, black* and *grey* once each. Total, red and yellow 14 times, blue and green 8 times. I obtain pretty similar proportions in many other cases.

And now let us turn to our final question—the examination of the Homeric and Hebrew colour-vocabulary.

As regards the Akhaians, Mr. Gladstone tells us that they could not have understood real colours by their apparent colour terms, because the words are used so loosely. An adjective here applied to a red object is there applied to a black one. Here, green means green; there, it means fresh or young. So be it. Has Mr. Gladstone never heard of red blood, red skies, red bricks, and red Indians? Do Englishmen never talk of a green old age, or Americans of green corn, which is really pale yellow? Is not red blood confronted with *sangre azul,* and red wine with the *petit vin bleu?* When an untrained speaker talks of purple does he not mean violet, and when he talks of violet does he not mean ultramarine? Did any man ever really possess red hair or blue eyes? In short, are not colour terms always vague, and are they not vaguer in the idealised language of poetry than anywhere else? The later Greeks were themselves aware of the deficiency in their colour-vocabulary, as is shown by a passage in Athenæus ("Deipnosophists," xviii. 31).[1] Mr. Gladstone's

[1] My attention was called to this passage by a note of Professor Robertson Smith in "Nature," December 6th, 1877.

microscope has brought out one result, let us see what result the comparative method will bring out on the other hand. I shall take the liberty of dogmatising in opposition to his dogmatism, and I shall leave the decision between us in the hands of the critical reader.[1]

The Homeric Akhaians were a sub-barbaric race, who had reached the stage of culture at which the use of pigments is practised, but who only employed red and a reddish purple in staining or dyeing. Their colour-vocabulary is exactly accommodated to such a stage. One true abstract adjective exists for the colour red; two pigmentary adjectives express the red dye and the reddish purple dye; a second abstract adjective denotes yellow; and all other hues are designated by metaphorical colour-terms. Furthermore, light and shade adjectives and glitter adjectives naturally preponderate over true colour epithets; because metals and precious stones, together with such other similar objects as ivory and horn, were more prized than dyes or pigments.

The abstract red colour epithet is *eruthros.* This is an ancient Aryan word, whose derivatives express the idea of redness in all the languages in which they occur. It would be hopeless now to decide whether it was originally a pigmentary or a metaphorical adjective. Long before the age at which the Homeric ballad-writers lived, it had become a true abstract word. That it meant *red* and nothing else is clear, not only from the cognate languages, but also from its being applied to only four objects, namely, copper (Iliad, ix. 365), nectar (Iliad, xix. 38; Odyssey, v. 93), wine (Odyssey, v. 165; ix. 163, 208; xii. 19, 327; xiii. 69; and xvi. 444), and blood (Iliad, x. 484; xxi. 21), every one of which is red. When we say *red*

[1] Were this a mere specialist question of Greek scholarship I would not for a moment claim to be heard upon it. I make no pretensions to minute classical knowledge; but I can read my Homeric authors, and I judge them by comparison with the language and the arts of people in a corresponding stage of culture elsewhere. The matter is one for the ethnologist and the psychologist, not for the professed Grecian.

we mean *red*, and not crimson, scarlet, russet, or any subspecies.

The red pigmentary epithet is some compound of *phoinix*. What the material so named may have been we cannot know with certainty; but the uses of the word show clearly that it was a bright scarlet. In Iliad, iv. 141, it is mentioned as a stain employed in decorating ivory to form an adjunct of chieftainship, and its colour is there described as like that of fresh blood, flowing from an open wound. Nothing could be clearer or more explicit than this, and nobody but a theory-maker could mistake its meaning. That one passage is quite enough to show that the Akhaians saw red. To suppose that a race devoid of colour-sense would take the trouble to use dyes is about as rational as to suppose that a race of deaf-mutes would spend their time in the manufacture of pianos. Elsewhere the word (or its derivative) is applied to a red horse and a red lion. As a blood epithet it occurs in one form or another six times (Iliad, xii. 202, 220; xvi. 159; xviii. 538; xxiii. 716; Odyssey, xviii. 96). It is also used for cloaks and mantles, which are never called *eruthros*, and for a very good reason; the pure abstract colour epithet is applied to wine, copper, and blood, which are self-coloured; but the pigmentary adjective is naturally given to the artificial objects stained with it. Thus the girdle in Iliad, vi. 219; vii. 305 and Odyssey, xxiii. 201, is said to be dyed with *phoinix*. So, too, are the prows of ships, like the war-canoes of so many savage tribes, in the phrase *phoinikoparêos*. Of course, the word is sometimes extended to naturally-coloured objects—blood, horses, and jackals—but the primitive pigmentary sense is pronounced throughout, and the transference is too easy and simple to call for special explanation.

A minor red pigmentary adjective is *miltoparêos*, also applied to the war-canoes. The milt may very likely have been an ochreous earth. It occurs in too specialised a connection to hazard a guess upon its exact hue.

The reddish purple pigmentary adjective is *porphureos*. There is very little reason to doubt that this applies to the Tyrian murex dye. At any rate, it was a stain employed for artificial colouring, and its derivation is from a verb meaning *to mix together*, or, more literally, *to middle-muddle*. Its commonest use is in connection with clothing, especially the clothing of the chieftains. The word is employed as an epithet of carpets (Iliad, ix. 200, Odyssey, xx. 278), coverlets (Iliad, xxiv. 643), mantles (Odyssey, xix. 225), cloaks (Iliad, viii. 221, Odyssey, viii. 85), clothing (Odyssey, xiii. 108), gowns (Iliad, xxiv. 796), the web in spinning (Iliad, iii. 125; xxii. 441), and the wool on the distaff (Odyssey, vi. 53, 306). It is also applied to a sort of cricket ball (Odyssey, viii. 373). In all these cases, it refers to objects actually dyed with the pigment. As a secondary colour epithet it occurs with reference to the purple rainbow (Iliad, xvii. 547), the purple stream of blood (Iliad, xvii. 361), the purple sea (Iliad, i. 482, and three times elsewhere), and the purpling of the soul in terror (Iliad, xxi. 551).

The other red epithets are metaphorical. They include "rose-like" *rhodoeis*, "wine-faced" *oinops*, and "pretty-cheeked" *kalliparêos*.

The abstract yellow colour epithet is *xanthos*. It is applied to human hair, to horses, and to the brook of that name. But in the Homeric poems, as in all other poetical writing, yellow is generally described by *gold* or *golden*.

Blue has only two words, both metaphorical. The first, *huakinthinos*, is derived from some flower, possibly a hyacinth. It occurs but sparingly. The second word, *ioeis* or *ioeidês*, is undoubtedly the colour of the violet—that is, ultramarine. The sea is three times spoken of as "violet-faced" (Iliad, ix. 298; Odyssey, v. 55; xi. 106), and it cannot be denied that the sea is sometimes (though rarely) blue. 'Violetish' is also used of blue steel. We must remember, in this connection, that the pottery of Troy and Mycenæ is coloured red and yellow, never blue. But once, in Odyssey, iv. 135, we get the startling word, *iodnephes*, "violet-darkened," or dyed blue, applied to wool. This would seem as though towards the close of the epic period, when the Odyssean ballads were composed, a blue dye began to make its appearance. On this point we shall find hereafter a Hebrew analogy.

Green is always designated by "grass-like" (*khlôros*). The derivation is from *khloê*, herbage. The word is seldom applied to literally green objects, because such are generally leaves or other vegetal products, of which the name alone is sufficient to describe the colour. The ballad-maker loves to dwell on red wine, scarlet robes, purple carpets, golden helmets, glistening bronze; but why should he need to tell us about the common green leaves or the blue sky overhead? These things belong to the poetry of civilised man, the town dweller; but they find no natural place in the rude songs which tell the tale of savage royalty and bloody fights.

Herein we get the real secret of the Akhaian colour nomenclature. The many brilliant objects of external nature for which we require such varied names—the flowers, the birds, the butterflies—these were of little importance in the eyes of those bloodthirsty warriors, whose greatest joy was the *kharmê*, the battle-ecstasy, the delight in slaying. Only a very few flowers have separate names in the poet's vocabulary: as a rule mere vague references suffice for all his needs. The objects which he most wishes to describe are men, horses, cattle, whose hues are indefinite, impure, and very variable in different individuals. Bronze, gold, silver, garments, war-canoes, royal furniture, sceptres, and rude palaces, these supply him with a few epithets of dyes or natural colours. But when he turns to nature, it is the great wholes alone which attract his attention; the sea, white, or blue, or green, or grey, or purple, in its changeful moods; the sky, coppery, or azure, or leaden, or black with storm-clouds, or crimson with the sunset, or gilded with the rays of dawn. Earth, mountains, rivers, sands, and rocks, all these afford him no fixed and regular sensations. Hence his language is necessarily indefinite and vague. The epithet that suited the sea in this line suits the sky in that. What is the colour of a horse, of a cow, of the human race, of water, of clouds, of the ship under weigh? Red, or black, or white, or grey, or what you will.

In truth, the primitive man shows his acute colour perceptions by the accurate manner in which he detects faint undertones of hues hardly suspected at a first rough glance. How sharp is the eye which notes the almost imperceptible tinge of greenness in the face of fear, and likens it at once to the full green of grass? How keen is the sense which catches the slight difference of shade between the black Douglas and the red Douglas, between the O'Connor Don and the O'Connor Roe! The most insignificant trace of ruddiness in the soil entitles a place to be called *Edom*, *Eruthrai*, or *Rutland;* the merest suspicion of yellow gives us such names as *Xanthos* and *Hoang Ho.* In short, if one object be a little darker than another, the quick-minded savage calls it black; if it have a tiny infusion of blueness, he says it is sky-faced.

As for the indirect traces of colour-perception in the Homeric poems, I need only point to such casual references in the Iliad as "saffron-robed Dawn" (Iliad, viii. 1); the many-coloured metals of Agamemnon's armour (xi. 15); the jewelled girdle of Aphrodite (xiv. 181); the silver, gold, bronze, and tin of Akhilles' shield (xviii. 474); or the cup, "wrought by cunning Sidonian workmen, and brought by Phœnician men across the sky-blue sea" (xxiii. 743). Then there are the occasional references to flowers, roses, violets, hyacinths, and crocuses. But perhaps the best proof of all is that afforded by the wardrobe of Hekabê, "wherein were her many-coloured (*pampoikiloi*) robes, Sidonian women's work, which god-like Alexander brought himself from Sidon-land, sailing across the mighty sea." Amongst all these, Hekabê chose for Athênê "that which was loveliest in figured dyes (*poikilmasin*), and largest eke, and as some star it shone;" and rosy-cheeked Theanô laid it on the knees of the golden-haired, hazel-eyed goddess. How singularly appropriate all these phrases would sound in the mouth of a poet who did not know one colour from another!

And now let us pass on to Geiger's instance of the ancient Hebrews. Here I can only trust to the Authorised Version of the early books, for I am no Hebraist; but I have secured the kind assistance of a distinguished specialist, the Rev. T. K. Cheyne, and I venture to submit my results as follows:—

The Hebrews of the kingly age were one step in advance of the Homeric Akhaians, as regards their employment of pigments, and the wealth of their colour-vocabulary. This might naturally be expected from their closer connection with the civilised communities of Egypt and Assyria. They appear to have employed three pigments, a red, a purple, and a blue; and they had a word in common use for green.

The history (or legend) of the Tabernacle gives an account of the objects to be offered for sacred purposes, which include "gold, and silver, and brass; *and blue, and purple, and scarlet;* and fine linen, and goats' hair; and *rams' skins dyed red,* and badgers' skins; and shittim wood; oil for the light, spices for anointing oil, and for sweet incense; onyx stones, and stones to be set in the ephod and in the breastplate."[1] The curtains of the Tabernacle were to be made of "fine twined linen, and blue and purple and scarlet,"[2] and fringed with "loops of blue." The same stereotyped conjunction of "blue and purple and scarlet" reappears, with true Hebrew monotony, in the veil (Exod. xxvi. 31), the hanging for the door (xxvi. 36), the gate of the court (xxvii. 16), and elsewhere during the subse-

[1] Exod. xxv. 4–7. I have quoted this passage entire, because it illustrates well the æsthetic stage of the time when it was written, though, of course, the date of its composition is purely conjectural.

[2] Ibid. xxvi. 1.

quent chapters no less than nine times. Various minor portions of the sacerdotal costume are specially restricted to one hue. Gold and other precious objects occur in profusion.

The account of Solomon's Temple shows the same three prevalent colours, and no others, used as pigments.[1] As before, the veil was made "of blue and purple and crimson and fine linen,"[2] under the direction of a half-caste Phœnician, whose father was a man of Tyre, "skilful to work in gold and in silver, in brass, in iron, in stone, and in timber; in purple, in blue, and in fine linen, and in crimson; also to grave any manner of graving, and to find out every device."[3] To multiply examples would only prove tedious to the reader, without adding materially to the argument.

I learn from Mr. Cheyne that these words might be more correctly translated *blue-purple*, *red-purple*, and *crimson*. The first two colours were obtained from mollusca, and the third from the cochineal-insect. The derivations of the words meaning *blue-purple* and *red-purple* are unknown, but they occur in the same combination in Assyrian; that of the third is from the Hebrew word for "a worm." The term translated *crimson* in the Chronicles is a later name for the same colour which is called *scarlet* in Exodus, and its origin is perhaps Persian.

Furthermore, the allusions to precious stones (whether the words referring to them be correctly translated in every case or otherwise) clearly exhibit the æsthetic standing of the people. The breastplate of judgment contained twelve jewels—sardius, topaz, carbuncle, emerald, sapphire, diamond, ligure, agate, amethyst, beryl, onyx,

[1] I give no opinion upon the chronological and historical question, because I am not competent to form one. The date of the writer and the credibility of the narrative, however, have as little to do with the fact of colour perception among the Hebrews as the existence of Agamemnon or the personality of the supposed Homer with the same fact among the early Akhaians.

[2] 2 Chron. iii. 15, *et al.* [3] Ibid. ii. 14.

and jasper.[1] The jewel called sapphire was certainly blue; for the "God of Israel" is described as standing on "a paved work of sapphire stone"—in other words, on the solid firmament.[2] Solomon's Temple was "garnished with precious stones for beauty,"[3] and other notices of the same sort occur elsewhere.

Besides these directly æsthetic accounts, we find scattered colour terms throughout all the books. In the very early myth of Joseph we read of a "coat of many colours."[4] "Ribbands of blue" were enjoined on the people in the desert.[5] Rahab agrees with the spies to hang out "scarlet thread" as a signal.[6] Tamar wears a "garment of divers colours, for with such robes were the king's virgin daughters apparelled."[7] Aholah, in Ezekiel's fable, doted on her lovers, the Assyrians, who were "clothed in blue;"[8] and Aholibah on "the images of the Chaldeans pourtrayed with vermilion," "exceeding in dyed attire upon their heads." Much doubt hangs over the first and fourth of these renderings; but I give them in the words of the Authorised Version (preserving the traditional belief) for what they may be worth.

Green, however, is never mentioned during the native kingly period as a decorative colour. "Green pastures" in Psalm xxiii. 2, "might be better translated 'tender grass;'" but we must remember that almost all words for green originally refer to growth or freshness. On the other hand, the "green herb" in Gen. i. 30 (literally "every greenness of herbage") has the notion of colour original, according to Mr. Cheyne, "or at least early reached by usage." The corresponding word in Arabic, a leading scholar in that language informs us, means rather grey than green: and this vagueness is exactly paralleled by that of the Greek *khlôros*. Both cases show, not that green was unperceived, but that it ranked low in æsthetic value.

[1] Exod. xxix. 17. [2] Ibid., xxiv. 10. [3] 2 Chron. iii. 6. [4] Gen. xxxvii. 3. [5] Numb. xv. 38. [6] Josh. ii. 18. [7] 2 Sam. xiii. 18. [8] Ezek. xxiii. 6.

Yet though green found no place in the decorations of the Tabernacle or the Temple, it is once mentioned in the Authorised Version, among the ornaments of a foreign court, when Ahasuerus the king feasted in Shushan the palace, "where were white, green, and blue hangings, fastened with cords of fine linen and purple to silver rings and pillars of marble: the beds were of gold and silver, upon a pavement of red, and blue, and white, and black marble."[1] Now, though Mr. Cheyne tells me that modern philology has decided in favour of the translation "cotton" instead of "green," yet when we examine the peculiar position of this word in the sentence, and then recollect the ancient Persian fondness for green, with the constant appearance of that hue on the Babylonian and Ninevite enamelled bricks, I can scarcely help believing that in this case the traditional rendering closely represents the truth. Mr. Cheyne himself, indeed, inclines to think that though the word means etymologically "cotton," yet some idea of colour (he suggests "variegated") is mixed up with it in practice. Perhaps, then, we may have here an analogous advance to that of the Akhaians from red, purple, and yellow decorations to the artistic employment of blue. In any case, we can scarcely doubt that the Hebrews after the Captivity must in great part have adopted the æsthetic standard of their Semitic and Aryan conquerors.

One final example of Mr. Gladstone's method must be given *àpropos* of the Hebrew colour-sense. Ezekiel describes in glowing language the truly oriental vision in which his poetic eye beheld in imagination the glories of the God of Israel. "Above the firmament," says the prophet, "was the likeness of a throne, as the appearance of a sapphire stone: and upon the likeness of the throne was the likeness as the appearance of a man upon it. And I saw as the colour of amber, as the appearance of fire round about within it . . . and it had brightness

[1] Esther i. 7.

round about. As the appearance of the bow that is in the cloud in the day of rain, so was the appearance of the brightness round about it." [1] Mr. Gladstone quotes in part this perfectly pellucid passage, and thus comments upon it: "Which cannot be explained but by supposing that, for the eye of the prophet, red was the fundamental, and exclusively prevailing, colour of the rainbow." Any unprejudiced person would have imagined that the words "could not be explained but by supposing" the prophet to mean exactly what he says—that a halo of every hue in the rainbow surrounded the sapphire throne, where the God of Israel was seated, begirt with amber flames, looking down upon the work which was like unto the colour of a beryl, and planting His foot on the firmament, whose appearance was of terrible crystal. But literal interpretation will sometimes lead men into a strange confusion of the obvious.

As for the Vedas, I shall not attempt to deal with them. That "book with seven seals," as Professor Max Müller calls it, can be easily made to prove that black is white, or *vice versa:* and therefore to juggle with its colours is a mere piece of simple conjuring. If the reader believes that the case for Dr. Magnus has broken down so far, he will hardly attach much importance to the doubtful utterances of the Sanskrit Scriptures.

And now that our review is completed, it may, perhaps, appear to some readers that, in combating this "historical development" theory, I have been really doing battle, like Don Quixote, with a perfectly harmless foe. Whereto I would respectfully answer that I seem rather to be performing the less romantic part of Sancho Panza. Sundry learned writers having discovered an imaginary giant, it becomes my humble duty, as a common-sense critic, to point out that the monstrous being is, in fact, nothing more nor less than a windmill. Such a task may be ungrateful and inglorious enough, but it remains none the

[1] Ezekiel i. 26.

less necessary for the prevention of further hallucinations on the same subject in future. When an honest and truthful knight solemnly assures us that he has met with a genuine giant, the world at large naturally accepts his statement in good faith, and goes on believing it until some lowly squire comes forward to sift the evidence upon which his assertion is based.

Finally, I hope that besides the negative task of demolition, we have been able, in the course of our argument, to build up some new and positive constructive work, which will throw fresh light both on æsthetic development and on the growth of special vocabularies. This must be my excuse for a digression which might at first sight have appeared to be leading us too far from the central subject, on whose consideration we are here engaged.

CHAPTER XIV.

SUMMARY AND RECAPITULATION.

Now that we have completed our survey of the Origin and Development of the Colour-Sense, we may briefly sum up, in a dogmatic form, the main results to which we have been led in the course of our investigation.

Colour, viewed objectively, consists in the different rapidity and wave-length of various æthereal undulations. These undulations, taken in their totality, are called light; taken in their several component parts, they are called colour.

The earliest animal eyes are cognisant of light and its negation only. Next, probably, came the discrimination of form. Last of all was developed the qualitative perception of colour.

This perception was apparently first aroused in the case of insects by the hues of flowers. The flowers were themselves developed by the action of the insect eyes, and they reacted simultaneously upon the senses of the insects to whose selection they were due.

In simple marine animals, the perception of colour was probably first aroused by the animal organisms in their environment. From them it was handed down to the fishes and reptiles, and more remotely to the birds and mammals. In the latter case, however, the sense may have been quickened and kept alive by its exercise upon coloured fruits, which were produced by the selective action of these great classes themselves.

The general existence of a colour-sense in insects and vertebrates is shown, in some cases, by direct experiment, in other cases by a large number of inferential proofs. It is a hypothesis which explains all the facts in the colouration of organic bodies, and without which the facts become a mere chaos of inexplicable caprices.

The constant employment of the colour-percipient structures in the search for food, amongst the flower-haunting and fruit-eating animals, would ultimately lead to the strengthening of those structures, and, consequently, to the development of a concomitant pleasure. This pleasure shows itself in the form of a taste for colour. Such a taste is found in a large majority of the species so circumstanced. It becomes manifest partly in the selection of bright foods, partly in a general love for brilliant objects, but most of all in the choice of gaily-coloured partners. To this cause we owe the beauty of butterflies, birds, and many other animals.

Besides this direct reaction of the colour-sense upon the external appearance of the creatures which possess it, an indirect reaction is exerted by the constant killing off of those individuals whose colouration specially exposes them to attack, and the survival of those individuals whose colouration affords them any means of protection, either through inconspicuousness, mimicry, or any other mode. In this manner a large number of animals have acquired the hues which they now display.

The quadrumana, being frugivorous animals, possess the colour-sense in a high degree. They show a considerable taste for bright colours, and their own appearance often betrays the action of sexual selection.

Man, the descendant of the frugivorous quadrumana, also possesses a very perfect colour-sense, which is equally evolved in all varieties of the species, from the highest to the lowest. A supposed linguistic proof to the contrary is not countenanced by the other facts of the case. Direct investigations show that all existing men have like colour-perceptions; and historical inquiry shows that the same is true of all earlier races.

Man derives from his frugivorous ancestors, not only the perception, but also the love of colour. This love is shown first in personal decoration, and is afterwards extended to the arts in general. The taste for colour at length affects almost every object of human industry; but it must all be originally referred to the habits of our frugivorous ancestors.

The vocabulary of colour, like all other vocabularies, springs up in proportion to the needs of the various languages.

The arts employ chiefly the colours which are least common in external nature, and which are also those employed by fruits and flowers for the attraction of animals generally. Poetry likewise uses them in the same proportions, but in an ideal form. The most advanced arts, however, use colour in more balanced quantities. But all art, decorative or imitative, retains to the last somewhat of its original character, as a direct stimulant of simple chromatic pleasure.

Thus the colour-sense, in its origin and its results, is seen to be one and continuous throughout. The highest æsthetic products of humanity form only the last link in a chain whose first link began with the insect's selection of bright-hued blossoms. The whole long series may be briefly summed up in some such formula as the following:—

Insects produce flowers. Flowers produce the colour-sense in insects. The colour-sense produces a taste for colour. The taste for colour produces butterflies and brilliant beetles. Birds and mammals produce fruits. Fruits produce a taste for colour in birds and mammals. The taste for colour produces the external hues of humming-birds, parrots, and monkeys. Man's frugivorous ancestry produces in him a similar taste; and that taste produces the various final results of human chromatic arts.

What a splendid and a noble prospect for humanity in its future evolutions may we not find in this thought, that from the coarse animal pleasure of beholding food mankind has already developed, through delicate gradations, our modern disinterested love for the glories of sunset and the melting shades of ocean, for the gorgeous pageantry of summer flowers, and the dying beauty of autumn leaves, for the exquisite harmony which reposes on the canvas of Titian, and the golden haze which glimmers over the dreamy visions of Turner! If man, base as he yet is, can nevertheless rise to-day in his highest moments so far above his sensuous self, what may he not hope to achieve hereafter, under the hallowing influence of those chaster and purer aspirations which are welling up within him even now toward the perfect day!

THE END.

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Vain Lagima y Umon